1988

An evaluation of the Defense Nuclear Agency exploratory development program in support of TNF C3 survivability (support of V Corps/8ID dispersed command post) using MCES

Maggitti, Paul V.

Monterey, California. Naval Postgraduate School

NAVAL POSTGRADUATE SCHOOL

Monterey, California

THESIS

An Evaluation of the Defense Nuclear Agency Exploratory Development Program in Support of TNF C3 Survivability (Support of V Corps/8ID Dispersed Command Post) Using MCES

by

Paul V. Maggitti

March 1988

Thesis Advisor: Major Thomas J. Brown

Unclassified

Security Classification of this page

REPORT DOCUMENTATION PAGE

1a Report Security Classification Unclassified	1b Restrictive Markings
2a Security Classification Authority	3 Distribution Availability of Report
2b Declassification/Downgrading Schedule	Approved for public release; distribution is unlimited.
4 Performing Organization Report Number(s)	5 Monitoring Organization Report Number(s)
6a Name of Performing Organization Naval Postgraduate School / 6b Office Symbol *(If Applicable)* 52	7a Name of Monitoring Organization Naval Postgraduate School
6c Address *(city, state, and ZIP code)* Monterey, CA 93943-5000	7b Address *(city, state, and ZIP code)* Monterey, CA 93943-5000
8a Name of Funding/Sponsoring Organization / 8b Office Symbol *(If Applicable)*	9 Procurement Instrument Identification Number
8c Address *(city, state, and ZIP code)*	10 Source of Funding Numbers

Program Element Number	Project No	Task No	Work Unit Accession No

11 Title *(Include Security Classification)* An Evaluation of the Defense Nuclear Agency Exploratory Development Program in Support of TNF C3 Survivability (Support of V Corps/8ID Dispersed Command Post) Using MCES

12 Personal Author(s) Paul V. Maggitti

13a Type of Report	13b Time Covered	14 Date of Report *(year, month,day)*	15 Page Count
Master's Thesis	From To	March 1988	264

16 Supplementary Notation The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.

17 Cosati Codes			18 Subject Terms *(continue on reverse if necessary and identify by block number)*
Field	Group	Subgroup	Modular Command and Control Evaluation Structure (MCES), Staff Planning and Decision Support System (SPADS), Exploratory Development Program, Command, Control and Communications, Command and Control (cont on reverse)

19 Abstract *(continue on reverse if necessary and identify by block number*

The purpose of this thesis is to evaluate the Staff Planning and Decision Support System (SPADS). The analysis presented uses the Modular Command and Control Evaluation Structure (MCES), a structured approach to evaluate C^2 systems using standard and evolving operational research tools. The analysis answered the following three problems by assessing the effectiveness of SPADS. Did SPADS provide the V Corps commander and his staff with the ability to exercise command and control of combat assets to meet overall mission objectives? Did SPADS demonstrate that the dispersed command post concept enhanced command survivability? Did SPADS evolve as a command and control force effectiveness system for the V Corps DCP based upon operational lessons learned? Appropriate measures of performance, effectiveness, and force effectiveness were identified to answer these problems. These measures and their assessment are presented as a strawman for consideration by the analytical community. As SPADS evolved from August 1981 to March 1985, it provided distinct advantages to the V Corps commander and his staff in terms of effective C^2 mission orientation, enhanced command survivability, and increased C^2 force effectiveness.

20 Distribution/Availability of Abstract [X] unclassified/unlimited [ ] same as report [ ] DTIC users	21 Abstract Security Classification Unclassified	
22a Name of Responsible Individual MAJ Thomas J. Brown, USAF	22b Telephone *(Include Area code)* (408) 646-2772	22c Office Symbol 62Bb

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted security classification of this page

All other editions are obsolete Unclassified

Item 18 Cont'd

C3 survivability, C3 systems architecture, C3 system requirements, C2 force effectiveness, C2 system effectiveness, C2 mission orientation, Command Survivability, Dispersed command post (DCP) concept, Non-developmental items (NDI) acquisition, Evolutionary development approach, Transportable C2 concepts, Proof of concept (POCE) testbed, Corps Tactical Operations Center (CTOC), Distributed information processing system, Command post support system

Approved for public release; distribution is unlimited.

An Evaluation of the Defense Nuclear Agency Exploratory Development Program in Support of TNF C3 Survivability (Support of V Corps/8ID Dispersed Command Post) Using MCES

by

Paul V. Maggitti
Captain, U.S. Army
B.S., North Carolina State University, 1981

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY
(Command, Control and Communications)

ABSTRACT

The purpose of this thesis is to evaluate the Staff Planning and Decision Support System (SPADS). The analysis presented uses the Modular Command and Control Evaluation Structure (MCES), a structured approach to evaluate C^2 systems using standard and evolving operational research tools. The analysis answered the following three problems by assessing the effectiveness of SPADS. Did SPADS provide the V Corps commander and his staff with the ability to exercise command and control of combat assets to meet overall mission objectives? Did SPADS demonstrate that the dispersed command post concept enhanced command survivability? Did SPADS evolve as a command and control force effectiveness system for the V Corps DCP based upon operational lessons learned? Appropriate measures of performance, effectiveness, and force effectiveness were identified to answer these problems. These measures and their assessment are presented as a strawman for consideration by the analytical community. As SPADS evolved from August 1981 to March 1985, it provided distinct advantages to the V Corps commander and his staff in terms of effective C^2 mission orientation, enhanced command survivability, and increased C^2 force effectiveness.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

I would like to take this opportunity to thank Dr. Ricki Sweet for her assistance and guidance in the development and completion of this thesis. Her contributions significantly increased the learning value of this effort. I would like to extend a special thanks to Major Thomas J. Brown, USAF, for his outstanding effort in making this thesis a better document. Major Brown's assistance in working with the Macintosh computer added immeasurably to what I gained from this experience. I must recognize the special trust that Lieutenant Colonel George Blood, USA, placed in me in 1983 when he selected me to be a member of the V Corps Command and Control Initiatives Office. In addition, I would like to thank all of the members of the C2IO and CCA for their assistance in helping learn what the Staff Planning and Decision Support System was all about. Finally, a very special thank you to my wife, Kathryn Markle, whose editorial expertise, assistance, and support made this effort considerably easier.

I. INTRODUCTION

The purpose of this thesis is to present an analysis of the Staff Planning and Decision Support System (SPADS). This system was a Defense Nuclear Agency (DNA) exploratory development initiative in response to U.S. Army requirements for Command, Control and Communication (C^3) survivability of theater nuclear forces. The V Corps dispersed command post (DCP) concept was the basis for enhancing survivability. In its acquisition, SPADS represents an evolutionary development with each phase based upon the results of lessons learned during field exercises in central West Germany.

The analysis presented uses the Modular Command and Control Evaluation Structure (MCES) to assess the effectiveness of SPADS. MCES is a structured approach to evaluate C^3 systems using standard and evolving operational research tools. Previous applications of MCES at the Naval Postgraduate School (NPS) have focused on theater-level and higher C^2 issues. A common characteristic of these analyses was the future focus on evaluating systems and testbeds. This is the first MCES-based evaluation of a tactical C^3 system that evolved from its conceptual stage to operational performance.

A. MCES EVOLUTION

The initial development of MCES grew out of a challenge to determine the force effectiveness of C^2 systems. A methodology was needed to describe C^2 systems architecture which would allow analysts to measure C^2 systems response and attribute the effectiveness of that response to the elements and/or structural relationships which form the C2 system [Ref. 1:p. 13]. In 1984 Dr. Ricki Sweet and Lt. Col. Thomas Fagan III chaired a conference which focused on identifying issues and topics an analyst would address

when evaluating a C^2 system in terms of its contribution to force effectiveness. Five working groups were formed to address the following subjects: Definitions, Conceptual Models, the Identification of Measures of Effectiveness (MOEs), Evaluation Techniques and Approaches, and an overall appraisal of the current status and future course of MOE analysts [Ref. 1:pp 24-27].

Subsequent workshops and conferences further defined expressed interests in and the need for further attention to C^2 systems. A "strawman" was developed by Drs. Morton Metersky, Michael Sovereign and Ricki Sweet to provide a framework for effectiveness analysts and deliberation at the 1985 Military Operations Research Society (MORS) sponsored workshop. This led to the publishing of an integrated document describing MCES in June 1986.

MCES was designed to be applicable to any C^2 system, to be modified or altered to fit any C^2 system of interest. MCES methodology continues to evolve in order to resolve key C^2 issues. New C^2 tools and models have been identified, developed and integrated into MCES.

Numerous efforts at NPS have been directed towards the application of MCES to various command and control issues. During the last two years, six master's of science degree theses have been completed using MCES at NPS. These theses spanned the range from applying MCES as a framework for acquistion management to analyzing the Identification Friend, Foe or Neutral (IFFN) Joint Testbed to evaluating C^2 components of the Strategic Defense Initiative (SDI) architecture.

B. MCES METHODOLOGY

MCES was developed during the 1980s as a structured approach to evaluate C^2 systems and architectures. MCES defines "architecture" as a description of an integrated set of systems whose physical entities, structure, and functions are coherently related. This

representation of the architecture provides the ability to measure the C^2 system response and its effectiveness in directing forces to accomplish their mission. MCES uses standard and evolving operations research tools, and attempts to integrate previous, diverse efforts of decision makers and analysts to provide a concise C^2 evaluation structure [Ref. 1:p. 13].

MCES is composed of seven sequential modules which guide an analyst through a comprehensive C^2 evaluation. Figure 1.1 presents the graphic structure of MCES methodology.

The first module is used by both the analyst and the operational user to specify the particular C^2 problem. The next three modules employ the terminology and theory of MCES to describe the C^2 system architecture. This permits the analyst to model the C^2 system and its operation. The methodology integrates the physical elements of the system with its process functions into a structural framework. In the fifth module, measures are identified, based upon the C^2 system bounding, which will be used to evaluate the C^2 architecture. The sixth module requires appropriate data for measurement. The seventh module aggregates and evaluates the results for presentation to the decision maker [Ref. 2:pp. 10-23]. (A more detailed explanation of how MCES is applied is provided in Appendix D.)

C. SPADS BACKGROUND

The U.S. Army V Corps, headquartered in Frankfurt, West Germany, attempted to employ a dispersed command post (DCP) configuration in the early 1980s. Despite early success with concepts and their employment, the corps was constrained by Army hardware and doctrine. Following several exercises that employed the early Target Acquisition and

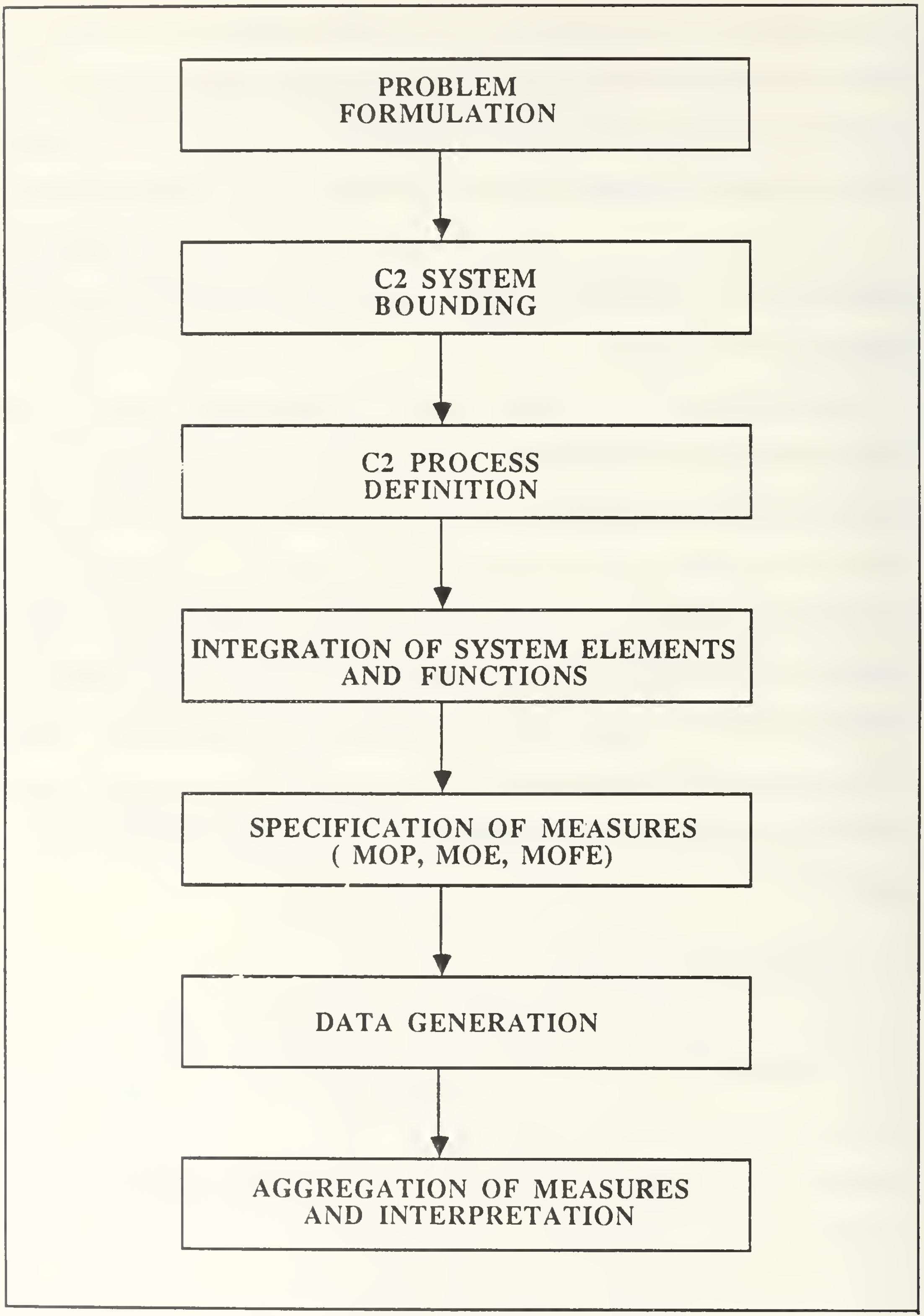

Figure 1.1. Modular Command and Control Evaluation Structure

Planning (TAP) microcomputer workstations, V Corps requested assistance from DNA for the implementation of their DCP concept. In September 1981, DNA introduced the Staff Planning and Decision Support (SPADS) system at V Corps as the focus of its "Exploratory Development Program (EDP) in Support of TNF C^3 Survivability (Support of V Corps/8ID Dispersed Command Post)." DNA employed V Corps as the proof of concept experiment (POCE) testbed for SPADS from September 1981 through December 1984. V Corps energetically used this evolutionary command and control system in every field training and command post exercise throughout the 1980s.

The dispersed command post concept was the basis for enhancing survivability. V Corps Headquarters operated from dispersed cells, representing the traditional Corps Tactical Operations Center (CTOC), rather than from one large center that could present a lucrative target. The communications links between and among the dispersed cells were provided by the Army's Tactical Area Switching System (TASS).

SPADS was a distributed information processing system that supported C^3 functions at multiple geographic locations. The system was designed for use in vans, tents, buildings, or armored command vehicles by functional staff personnel and commanders. The SPADS architecture consisted of a co-located group of staff duty stations linked by a local area network to form a module. Several modules were then interconnected by communication gateways through Army tactical communications to form a distributed, wide area network. The capabilities of the staff duty stations consisted of text editing, electronic mail, graphics and overlays, a relational database management system, map and photo correlation, spreadsheet models, and functional area algorithms.

D. NATURE OF THE PROBLEM

This thesis addresses the question: How effective was the SPADS system in the V Corps sector of the Central Army Group (CENTAG) region in: (1) providing decision

makers with the means to access and employ their combat assets to meet overall mission objectives; (2) demonstrating that the DCP concept enhanced command survivability; and (3) evolving as a command post support system, based upon operational lessons learned?

To elaborate, this thesis will specifically attempt to assess SPADS' effectiveness in the following three problem areas:

1. Did SPADS provide the V Corps commander and his staff with the ability to exercise command and control of combat assets to meet overall mission objectives?

2. Did SPADS demonstrate that the dispersed command post concept enhanced command survivability?

3. Did SPADS evolve as a command and control force effectiveness system for the V Corps DCP based upon operational lessons learned?

The resolution of the first problem requires a measure of effectiveness (MOFE) derived as a function of: (1) capability to achieve the C^3 system's objectives interpreted as a function of flexibility, availability, interoperability, and responsiveness; (2) structural components interpreted in terms of timeliness; and (3) the physical entities interpreted in terms of capacity.

The second problem addresses command survivability as a function of dispersion, redundancy, and continuity of operations. And the third problem measures--across levels of operational capacity--the evolution of C^2 force effectiveness together with survivability. This final measure of command and control growth is thus derived as a function of the MOFE from Problem 1 and the MOE from Problem 2, with respect to time.

Appropriate data for these three problems were gathered from after action reports, external evaluations, and operational experience. These data were generated during numerous field training and command post exercises from 1981 through 1985. A worksheet was developed to select specific data for the measures of performance, effectiveness, and force effectiveness.

As indicated in the preceeding paragraphs, several of the measures are functions of other, lower level measures. For the purpose of this thesis, the values are defined as the unweighted sum of the constituent measures of performance. Only replication and external validation can present more certainty on the assessment of factors and their aggregation. These measures and their assessment are presented as a strawman for consideration by the analytical community.

E. THESIS ORGANIZATION

This thesis summarizes how MCES methodology was specifically applied to evaluate the SPADS system. The doctrinal definition of a forward deployed, heavy corps is discussed in terms of MCES in Chapter II. Chapters III, IV and V present an MCES analysis of the three phases of the SPADS program. Finally, Chapter VI provides conclusions and recommendations concerning the SPADS program, evolutionary development, and the MCES methodology.

II. THE CORPS BASELINE

A. PROBLEM DEFINITION

1. Background

In the early 1980s, existing and projected Army communications systems inhibited rather than enabled command mobility. The standard small set of known, fixed command posts and communications nodes was vulnerable to disruption and destruction by Soviet radio electronic combat units. One solution to this vulnerability was to dramatically increase the number of C3 targets and mobility and to achieve position location uncertainty. There were other technical alternatives, but military application of these technologies resulted in prohibitive unit costs and frequent program curtailment or termination. Some means had to be found to substantially lower survivability costs.

Potential solutions started to surface in military efforts to exploit the growing power of the microprocessor. The DNA, the Army's Training and Doctrine Command (TRADOC), and V Corps all initiated programs to achieve enhanced C2 survivability which were heavily dependent on new approaches to communications and command post decision aids. By 1981 V Corps began vigorously testing innovative command and staff procedures to support command post (CP) survivability, mobility, and effectiveness. The corps main CP used a closed-circuit TV system to support command and staff briefings in the consolidated Corps Tactical Operations Center (CTOC). Original plans to disperse the CTOC had been defeated due to an inability to transmit a secure video signal carrying text and graphic information.

Meanwhile, TRADOC identified certain initiatives which the Army could pursue to enhance corps and division battle coordination efforts, including [Ref. 3:p 3-23]:

1. Dedicating intelligence (Intel) and fire support element (FSE) personnel to work continuously on analyzing data throughout the depth of the battlefield

2. Placing a field artillery officer in the CTOC support (formerly the intelligence) element to process quick reaction, perishable, high priority targets directly to the appropriate attack means

3. Dedicating a CTOC support element analyst to develop quick reaction priority targets

4. Co-locating and training the G2/G3, FSE, tactical command post (TAC CP), and other staff elements designated by the commander to ensure synchronization of the deep, close-in, and rear battles

5. Introducing the use of microcomputers in the FSE and CTOC support element to develop, analyze, and prioritize targets in a rapid and continuous manner

6. Using closed-circuit TV and non-voice data links among critical staff elements

During this same period, DNA fielded the experimental, microcomputer-based Target Acquisitions Planning (TAP) system in V Corps. The purpose of TAP was to develop, analyze, and prioritize artillery targets in a rapid and continuous manner.[1] The V Corps commander recognized a possible linkage between TAP and the efforts to disperse command posts. In May 1981, V Corps contacted DNA directly to request an expansion of the TAP program to support corps operations. First, V Corps requested that DNA provide personnel to conduct an in-depth analysis of corps requirements during the June 1981 command post exercise. Second, the commander requested that an expansion of the TAP program, geared to the corps dispersed command post concept, be tested in September during REFORGER 81. [Ref. 4:pp. 1-2]

---

[1]The TAP system employed microcomputer automation to provide an integrated capability for U.S. and NATO targeting staffs to identify Warsaw Pact echeloned forces in near real time. Intelligence and fire support staffs today employ TAP in conjunction with other automated systems to streamline the targeting process. It provides staff officers with an interim capability until such systems as All Source Analysis System (ASAS) and Advanced Field Artillery Tactical Data System (AFATDS) are fielded in the early 1990s. [Ref. 7:p. 27]

2. Dispersed Command Post Concept

The dispersed command post concept offers the possibility of reducing and/or disguising both the electronic and physical signatures of the consolidated CP. Nearly all of the communications and other electronic equipment, vehicles, and facilities found in the corps CP are also found in lower echelon CPs. If these assets could be reassembled as smaller modules and then dispersed on the battlefield, the enemy would find it very difficult to distinguish the main corps CP from many other, lower echelon CPs. In addition, once the CP is broken into smaller units, it is much easier to accommodate the components in civilian structures or small wooded areas. Supporting communications links could then be maintained at smaller regional nodes in a further effort to reduce the electronic signature.

The traditional corps CP configuration in the early 1980s presented a target of some 150-meter radius. Either a small nuclear weapon or a well-targeted conventional attack could have destroyed nearly all of the C2 capabilities. Given the "kill radius" of even small nuclear weapons against CPs and other C3 facilities, DNA recommended a DCP system that called for the dispersion of the corps main CP--particularly the CTOC--into several modules that would be separated by a minimum distance of ten kilometers. DNA envisioned that this system would be extended throughout the corps CPs and eventually down to the division CPs. The corps CP would then be dispersed throughout an area approximately 40 kilometers by 50 kilometers.

Despite expected difficulties in coordination, DNA concluded in 1981 that the DCP offered the greatest probability for the survivability of corps C2 on the modern battlefield. The conclusion reached by DNA was further reinforced by emerging U.S. Army doctrine revealed in TRADOC Pamphlet 525-5, The AirLand Battle and Corps 86, dated 25 March 1981, which strongly encouraged the dispersion of critical C2 facilities.

To test this concept, DNA felt it necessary to establish a proof of concept testbed at an operational corps. In May 1981, the V Corps Commanding General sent an electronic message to DNA requesting assistance with a concept to employ microcomputers to support C2 operations in a dispersed command post. DNA took this opportunity to establish a testbed at V Corps with the objective of proving the DCP concept while developing an automated C2 system to enable its effective test and evaluation.

3. Evolutionary Acquisition

> Evolutionary Acquisition (EA) is not a cure-all for the real or perceived ills of the U.S. acquisition process; but it does hold promise to help field command and control (C2) systems sooner, at lower cost and with higher user satisfaction than other approaches. [Ref. 5:p. 23]

The purpose of evolutionary acquisition is to be able to field critically needed operational capabilities (OCs) within six to 12 months, rather than the years that would be required under standard acquisition policies. Deployment of the initial operational capability (IOC) is accomplished during the first year. The operational users conduct studies and/or exercises in their own tactical environments with on-site technical assistance from the contractor. Command and control procedures—along with system capabilities—evolve and are tested and refined during each field test and exercise.

Two critical components of this approach are incremental testing and user involvement. Hirsch noted that:

> A premise involved in using EA [Evolutionary Acquisition] to acquire C2 systems is that C2 systems are tested incrementally to determine whether the core system (or core system plus incremental upgrades to that system) meets the operational requirement....Therefore, users gain more extensive experience and make recommendations for establishment of operational requirements for subsequent system increments. This process of requirement evolution and introduction of upgrades distinguishes the evolutionary approach from the more classic weapon acquisition process. [Ref. 5:p. 26]

Each operational capability cycle is repeated to respond to changing requirements, to counter the new threat systems or techniques, and to take advantage of new and rapidly maturing technologies. Enhancements to the system are made within each cycle by adding or replacing components and by integrating new software that is tailored to specific military requirements.

Subsequent operational capabilities consolidate incremental enhancements or involve complete system upgrades to take advantage of major advances in microcomputer technology. The result is a fully integrated system, tailored to meet the operational user's specific needs. The final operating capability remains undefined, due to the evolutionary nature of this developmental approach and the continued implementation of hardware and/or software modifications arising from user requirements.

Operational capability cycles can be of different lengths or quantity. Milestones are normally sequential but can overlap. The initial responsibility of the operational user is to develop valid requirements. This requires an understanding of procedures which can be automated to meet the user's operational needs. Once the hardware configurations and software utilities are designed, the operational user has to identify and develop data structures and select those procedures to be automated. At the same time, the operational user plans manpower and training requirements for the evolving system. How the commander ranks these responsibilities strongly determines the initial success—or lack thereof—of early exercises and tests.

4. SPADS Evolutionary Development

The SPADS evolutionary development approach arose from the evolutionary acquisition concept. This process was mandated by Department of Defense Instruction (DODI) 5000.2 (System Acquisition) which provided a method to rapidly refine an automated command and control system that employed state-of-the-art technology guided

by user requirements. DODI 5000.2 devised a new approach to counter the following impediments to rapid fielding of technological advances:

1. A ten-year lag between research and development (R&D) and effective system implementation, resulting in built-in obsolescence
2. The ineffectiveness of systems that cannot respond to changing U.S. Army doctrine
3. The lack of affordability of automated systems that are tailored to user requirements

SPADS evolutionary development produced its greatest benefits for V Corps when the operational users initiated a critical dialogue with DNA and the systems integrator. Hirsch noted that:

> In using EA [Evolutionary Acquisition] to acquire C2 systems, a major premise is that the real user–working in a close, continual relationship with the developer and supporter–should have a major voice in formulating operational requirements and defining detailed system characteristics. [Ref. 5:pp. 24-26]

As a consequence of this approach, the resulting SPADS system was smaller, lighter, more rapidly deployable, and required less manpower to operate and maintain.

5. Problem Focus

The three problems identified in Chapter I will be examined under four conditions throughout the remainder of this thesis. The four conditions consist of the V Corps baseline and the three SPADS operational capabilities (detailed in Chapters III through V). Each condition will be evaluated using MCES, then the problems will be addressed at the conclusion of each evaluation.

B. BOUNDING THE V CORPS SYSTEM

In the terms of MCES, the V Corps C2 system consists of: (1) physical entities—the equipment, personnel and command posts; (2) structure—the hierarchical relationships, staff procedures, concepts of operation and information flow patterns; and (3) the C2 process—what the command and control system was doing [Ref. 2:pp. 11-12]. (Appendix

E provides a detailed definition of the Army's forward deployed corps in terms of mission, organization, operational concepts, threats to the corps, commander and staff, command posts, and communications support.)

Emphasizing the battle management functions necessary to control a forward deployed corps in central West Germany, the V Corps C2 system could be defined structurally in terms of its hierarchical relationships, its geographical areas of responsibility within the Central Army Group (CENTAG), and the information flow patterns between command posts. Hierarchically, the corps received its commands from CENTAG; it had lateral relationships with the III (German) Korps to the north and the VII (U.S.) Corps to the south; it commanded the 3rd Armored Division (3AD), the 8th Infantry Division (8ID), the 11th Armored Cavalry Regiment (11ACR), the 12th Combat Aviation Group (12CAG), and numerous brigade-sized units.

From a geographic perspective, V Corps was responsible for approximately 37,500 square kilometers of real estate in the West German federal state of Hesse.

Information flowed vertically and horizontally throughout the corps. The V Corps main and rear CPs received orders and information, and reported to the CENTAG CP; the corps support command received information from and reported to U.S. Army Europe (USAREUR) headquarters; the V Corps CPs transmitted orders and information, and received reports from the divisions, the armored cavalry regiment, and the major combat support and combat service support units in the corps area of operations.

The V Corps headquarters was normally divided into three wartime command posts: the TAC CP, the main CP, and the rear CP. The TAC CP consisted of four armored command post vehicles, one platoon from the corps signal brigade, and necessary supporting vehicles. The TAC CP was 100 percent mobile and was capable of displacing every 12 to 24 hours. The main CP had very limited mobility and required considerable

time to displace. In addition, the main CP had prominent physical and electronic signatures that were very difficult to reduce. Like the main CP, the rear CP had limited mobility, many vehicles, and distinctive signatures.

Prior to the implementation of the dispersed command post concept, the corps command posts were the main CP, the rear CP, and the TAC CP. The main CP consisted of Communications, Intelligence, Tactical Operations, and Air Support Operations elements compressed into a 300- by 300-meter area. The critical Tactical Operations Center (TOC) consisted of the Command, G1 (Personnel and Administration), G3 (Operations and Plans), G2 (Intelligence), Engineer, Weather, Fire Support, and Targeting elements in a 75- by 75-meter area. During the same period, the division command posts were the main, rear, division TAC, and division rear CPs.

Once V Corps decided to pursue the DCP, there was a concerted effort to realign physical entities and structural components. The main CP was restructured into four modules that supported four battle tasks. The new modules were CTOC, Plans, FSE, and Intel. The CTOC was similarly restructured; its new elements became Command, G3 Operations (Opns), G2 Opns, G1 Opns, G4 Opns, Nuclear Biological Chemical (NBC), Engineer, and Corps Airspace Management Element (CAME) in addition to liaison officers from subordinated units, adjacent corps, and higher headquarters.

C. ANALYSIS OF THE V CORPS C2 PROCESS

To analyze the V Corps C2 process using MCES, it is necessary to specify the corps mission objectives, the commander's tasks, the staff functions, and the functions of each module in the three command posts.

1. Corps Mission Objectives

The V Corps mission objectives can be defined in terms of four battle tasks: management of the current battle, planning the future battle, planning and executing the

deep attack, and sustainment of the force [Ref. 6:p. 2]. The corps mission determines tasks to be performed and initiates the military decision making process, which proceeds in four phases: (1) collecting information; (2) planning—to include an estimate of the situation, a decision, and preparation of the operations plan; (3) issuing orders; and (4) supervising the execution of issued orders [Ref. 3:pp. 3-36 – 3-46].

2. Corps Commander's Tasks

In planning his battles, the corps commander analyzes his mission, defines tasks, establishes intelligence requirements and priorities, organizes the corps for combat, assigns missions and tasks to subordinate commanders, and sets priorities for combat, combat support, and combat service support units. In planning all operations, the corps commander must take into account available time and space required to defeat engaged enemy forces before divisions would have to fight follow-on forces. This becomes the "window" against which system performance must be assessed. As the plans are executed, the commander must be aggressive, demanding, and personally involved. The way the corps commander generates and applies combat power often decides the outcome of battles and campaigns. (Appendix E specifies the tasks performed by the commander in the forward deployed corps.)

3. Corps Staff Tasks

The commander requires assistance to assimilate information provided through the corps command and control system. He needs support to filter available information, demand more when the picture of the situation is not complete, analyze pertinent facts, and communicate decisions to the many people that must thoroughly understand his intent. The staff directs and coordinates execution of the commander's intent by providing the necessary control of the battle. Appendix C specifies those tasks completed by each staff section in the corps CP. [Ref. 7:p. 2-7]

4. Command Post Functions

The three wartime CPs of the V Corps Headquarters were identified in Section B. The orientation of the TAC CP is the most limited of the three command posts. With its focus on the close-in battle, the TAC CP monitors the deep and rear battles only for their impact on Forward Line of Own Troops (FLOT) operations. The main CP focuses on the deep battle. Although a major focus of the rear CP is to sustain operations in all three battles, it must also focus on fighting the rear battle. A major element of the rear CP is the rear area operations center (RAOC). The RAOC manages rear area protection, commands and controls rear area combat operations, provides current battle information to the rear CP, and acts as the alternate main CP. Appendix E presents the functions of each of the three V Corps command posts.

Each module of the corps main CP is organized to support one of the battle tasks of the V Corps mission objective [Ref. 5:pp. B-1-1 – B-4-1]:

1. The CTOC monitors the current situation in the corps sector and adjacent corps sectors. It allocates resources to major subordinated units in order to influence the current battle. The CTOC executes operations plans and operations orders. It ensures the availability of current battle information to all elements of the corps C2 structure with emphasis on decision making information required by the commander.
2. The FSE coordinates the attack of deep targets. The FSE also executes the attack of deep targets with air force support, organic missile artillery, and electronic warfare assets.
3. The Plans module translates the commander's guidance into appropriate priorities for the intelligence effort, target development, the deep attack, and resource allocations. The Plans module also incorporates priorities and guidance into operations plans.
4. The Intelligence module provides timely and reliable information on threat dispositions, capabilities, activities, and intentions. It tasks the intelligence collection assets to support operations plans. This module disseminates periodic intelligence reports to other modules, subordinate units, and higher headquarters. Finally, it nominates appropriate targets to the FSE.

D. V CORPS C2 SYSTEM ARCHITECTURE

The V Corps C2 system architecture is described by an integrated set of systems whose elements and functions are coherently related. The corps physical entities and structural components (described in Section B) are mapped to the C2 process definition (Section C). Figure 2.1 graphically represents this integration for the consolidated main command post. To construct the V Corps system architecture, it was necessary to map from the corps battle tasks--the highest level of this architecture--down to the module elements (or sub-elements) that perform the specific staff functions. (These functions are subdivided into specific tasks for each staff section or element in Appendix C.) First, the corps battle tasks were mapped to the corps CP functions. Next, the CP functions were decomposed into specific functions for each module. Then these specific functions were mapped to the module elements--or sub-elements--which perform them. Finally, the functions were mapped to the appropriate task of the particular element. Table 1 illustrates this mapping from one of the four corps battle tasks, "Manage the current battle," through one of the many CTOC functions, down to the specific tasks for each CTOC element, e.g., G3 Operations is tasked to "Monitor the current situation."

After these architectural relationships were identified, the MCES provided guidance for both qualitative and quantitative measures based upon the specific form of data generation selected.

E. SPECIFICATION OF MEASURES

1. Introduction

The purpose of this section is to identify, develop, and select measures that gauge the V Corps C2 system's response to directing forces. These measures will provide the values used to assess performance and effectiveness by comparison--both at any point in time, and

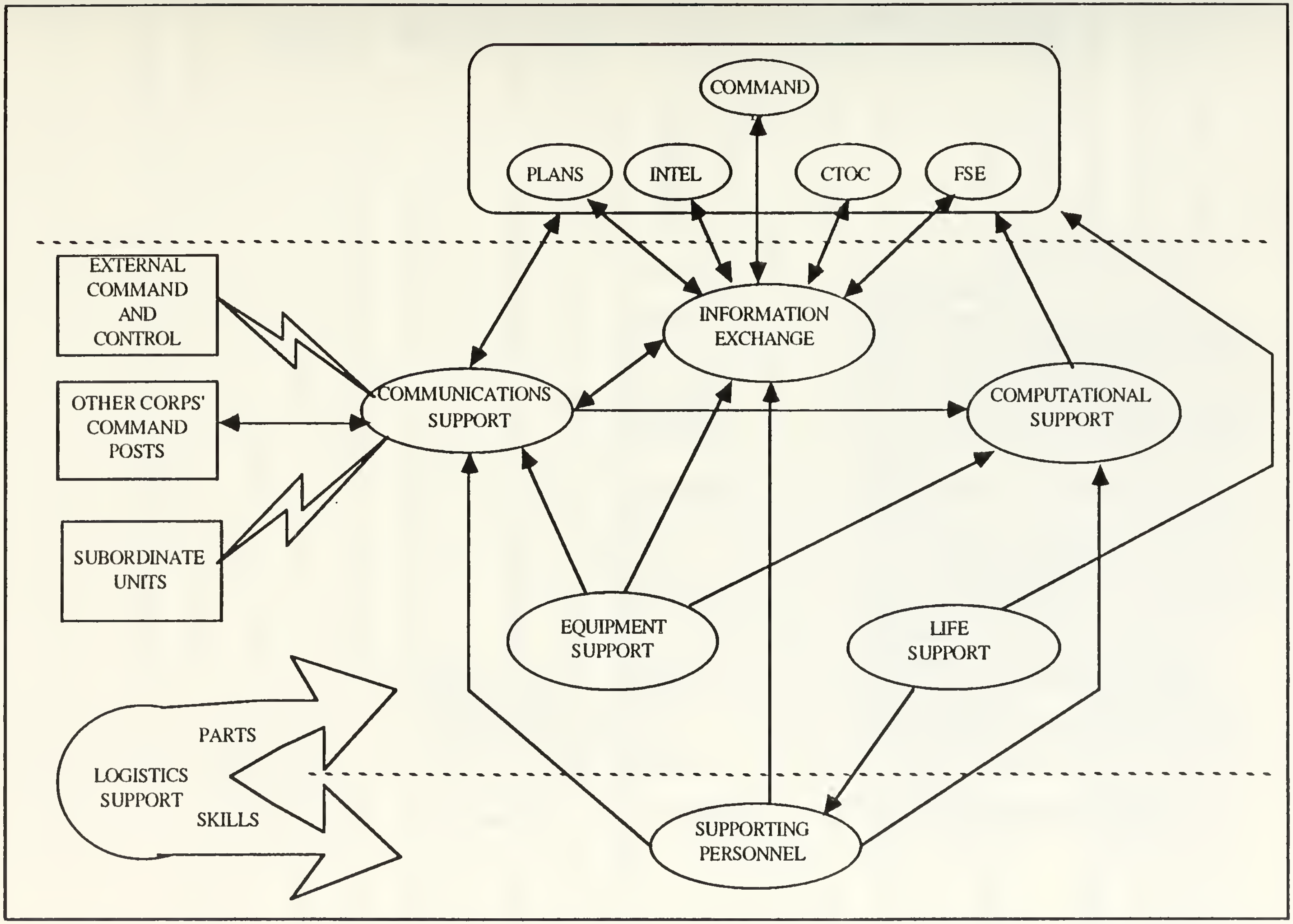

Fig. 2.1 Integration of System Elements and Functions in the Consolidated Main Command Post

Battle task	Main CP function	CTOC function	CTOC elements	Explanation of CTOC element tasks
Manage the current battle.	Current battle management.	Monitor the current situation in the corps sector and in the adjacent corps' sectors.	G3 Opns	Monitor the current situation.
			G2 Opns	Track the current battle with emphasis on the enemy situation.
			G1 Opns	Monitor the current personnel situation.
			G4 Opns	Monitor the current and essential logistics information.
			NBC	Monitor NBC messages.
			Engineer	Monitor the status of corps engineer units, barrier plans and completion status.
			CAME	Identify users/uses of the airspace throughout the corps sector.
			11 ACR LNO	Monitor the status of the 11th Armored Cavalry Regiment.
			8 ID LNO	Monitor the status of the 8th Infantry Division.
			3 AD LNO	Monitor the status of the 3rd Armored Division.
			RAOC LNO	Monitor the status and provide information about rear battle operations to G3 Opns. Provide current battle information to the RAOC.
			III (GE) Korps LNO	Monitor the current battle status within the III (GE) Korps sector.
			CENTAG LNO	Monitor the V Corps current situation.

Table 2.3 Mapping the C2 Process for a Single Corps Battle Task

as the underlying architecture of the C2 system changes from the V Corps baseline through the three operational capabilities. The measures are selected to relate directly to the architectural and operational issues posed in this analysis. It should be noted that additional measures might be useful for addressing another set of issues.

Three problems were identified in Chapter I. The first asks whether SPADS supported the V Corps commander as he exercised command and control of his combat assets to meet the mission objectives in the four corps battle tasks. The second asks whether the V Corps dispersed command post concept actually enhanced command survivability. The final problem questions whether the SPADS evolutionary development approach affected C2 force effectiveness throughout the three OCs.

2. Problem 1

Four measures of performance (MOPs) and two measures of effectiveness (MOEs) were initially selected for the first problem. The MOPs were: (1) flexibility, (2) availability, (3) interoperability, and (4) responsiveness. These MOPs specified performance inside the C2 system using the criteria "yes-it-works/no-it-doesn't-work" [Ref. 2:p. 97]. The MOEs were: (1) timeliness and (2) capacity; these address structural components and physical entities respectively. A third MOE was developed as a function of flexibility, availability, interoperability, and responsiveness (FAIR) to address the C2 process. Finally, a measure of force effectiveness (MOFE), addressing C2 mission orientation (${}^{X}MO_{Ti}$), was defined as a function of the C2 process, structural components, and physical entities. Table 2 defines the measures selected for this problem.

TABLE 2
MEASURES SELECTED FOR THE FIRST PROBLEM

Type	Name/Formula	Description
MOP	Flexibility	The capability to adapt rapidly to changing operational requirements (system configuration, threat, environment) with a minimum of disruption or delay.
MOP	Availability	Present or ready for immediate use.
MOP	Interoperability = f (Linkability + Usability)	
	Linkability	Systems can be physical linked together; this is associated with the physical entities.
	Usability	Systems can exchange services that are usable; this is associated with the structural components.
MOP	Responsiveness	Fits the users' impression: "quick to act appropriately;" the amount of time required to accomplish a task from beginning until end.
MOE	Timeliness = f (TimeElapsed/TimeWindow)	TE is the time it takes the critical amount of information to get from input to output (the commander or other critical decision maker). TW is the fixed amount of time available for the information to be received; this is a known window length with an unknown start time. Timeliness is interpreted as representative of the structural components.
MOE	Capacity = f (Saturation/Capability)	Capacity is the ability of a SPADS DCP module to contain, absorb, receive, store, perform or carry a certain amount of data, reports or functions during a certin period. Capacity is interpreted as representative of the physical entities.
MOE	FAIR = f (flexibility, availability, interoperability, reposiveness)	The C2 process is interpreted as a function of the summation of the values for the measures of flexibility, availability, interoperability and responsiveness (FAIR).
MOFE	C2 Mission Orientation, XMOTi	= f (FAIR, timeliness, capacity) Command and control mission orientation is an MOFE interpreted as the summation of the values for FAIR, timeliness and capacity.

3. Problem 2

In the second problem, the three MOPs selected were: (1) dispersion, (2) redundancy, and (3) continuity of operations [Ref. 6:pp. 1, B-1 - B-2]. The issue of command survivability ($^{X}CS_{Ti}$) was addressed by defining an MOE that was a function of the three MOPs. The selected measures are defined in Table 3.

4. Problem 3

The third problem was more challenging. SPADS *could not* evolve as a C2 force effectiveness system based upon operational lessons learned *unless* it: (1) provided the commander, and his staff, with the ability to exercise command and control of his combat assets to meet overall mission objectives; and (2) demonstrated that the dispersed command post concept enhanced command survivability. Therefore, an MOFE related to C2 force effectiveness (C2/FE) was defined in terms of C2 mission orientation in command survivability. C2 force effectiveness is defined in Table 4.

F. DATA GENERATION

Appropriate data for the measures specified in Section E were generated from after action reports, external evaluations, and operational experience. Data were generated during numerous field training and command post exercises throughout the three OCs. These exercises closely followed the general defense plans used by V Corps to train for combat operations. In each exercise, the C2 system was exercised by highly trained staff officers and NCOs who used the system as they would in a wartime environment.

The worksheet used to collect the data is shown in Table 5. This format was used for evaluating the three operational capabilities; the worksheet results are shown in Sections F and G of Chapters III, IV, and V. The corps baseline was evaluated using operational experience and doctrinal publications. After action reports were the principal source of data generation for the three operational capability cycles.

TABLE 3
MEASURES SELECTED FOR THE SECOND PROBLEM

Type	Name/Formula	Description
MOP	Dispersion	For minimum survivability from attack by tactical nuclear weapons or conventional artillery, all modules must be spaced a minimum 10 kilometer apart.
MOP	Redundancy = f (Key information elements + Distribution of skilled personnel)	
	Key information elements	100% of all required information elements are available at each module of the DCP.
	Distribution of skilled personnel	100% of the V Corps main CP functions are represented at each module of the DCP (CBM, Plans, FSM, Intel, Rear and TAC)
MOP	Continuity of operations = f (Reliability + Transportability)	
	Reliability	The system, subsytem or component satisfactorily performs its intended function all or a very high percentage of the time.
	Transportability	The system, subsystem or component is capable of being moved by assigned personnel and transported by organic assets; during movement, the mission is not performed.
MOE	Command survivability, XCSTi	= f (dispersion, redundancy, continuity of operations) Command survivability is an MOE interpreted as the summation of the values for dispersion, redundabcy and continuity of operations.

TABLE 4
MEASURE SELECTED FOR THE THIRD PROBLEM

Type	Name/Formula	Description
MOFE	C2 Force Effectiveness, C2/FE, at Ti	= f (XMOTi, XCSTi)
	Command and control force effectiveness of the V Corps Dispersed Command Post can be interpreted, at the conclusion of an operational capability, as the summation of the values for command and control mission orientation, XMOTi, and command survivability, XCSTi.	

Each measure listed in Tables 1 through 3 was evaluated as a binary condition. The measure received a single, unweighted digit if it met the condition "the description of the measure in the table is *true*." Using the worksheet shown in Table 5, each module present during that exercise was evaluated for every measure. The results on the worksheet were columns consisting of ones and zeroes. Every summed measure (e.g.,FAIR, XMOTi, and XCSTi) received a cumulative, unweighted score on the worksheet. The final measure, C2/FE, was computed using the description in Table 4, and the result was placed on the worksheet. The results of these evaluations are displayed in tables in Section F of Chapters III, IV, and V. In addition, the means of each measure for the entire operational capability cycle are displayed in figures immediately following the tables.

Two indicators of bias in the underlying data must be discussed. The first is missing data; in certain after action reports specific activities are absent and cannot be inferred. The second is observer unreliability; there are clear differences in both style and content between different writers of the after action reports. [Ref. 2:pp. 57-58]

TABLE 5
DATA GENERATION WORKSHEET

______Baseline ______OC1 ______OC2 ______OC3 Exercise: ________________

	Main CP				TAC CP	REAR CP
	CTOC	PLANS	FSE	INTEL		
Problem 1:						
FAIR						
• Flexibility						
• Availability						
• Interoperability						
• Linkability						
• Usability						
• Responsiveness						
• Hardware						
• Software						
TIMELINESS						
CAPACITY						
XMOTi						
Problem 2:						
DISPERSION						
REDUNDANCY						
• Key Info Elements						
• Skilled Personnel						
CONTINUITY						
• Reliability						
• Transportability						
XCSTi						
Problem 3:						
C2/FE						

G. AGGREGATION AND INTERPRETATION OF MEASURES

1. General

Problem 1 addresses command and control as a measure of force effectiveness derived as a linear function of the values for:

1. Mission orientation—the C2 process—which itself is interpreted as the summation of the values derived for flexibility, availability, interoperability, and responsiveness (FAIR)
2. Structural components interpreted as a measure of timeliness
3. Physical entities as a function of capacity

Problem 2 addresses survivability as a measure of effectiveness derived for dispersion and redundancy.

In Problem 3, the measure of command and control force effectiveness is derived from the linear aggregation of the value derived for the MOFE from Problem 1 and the value of the MOE from Problem 2. The command and control force effectiveness of the V Corps CP was measured, at the conclusion of an operational capability, by adding the values derived for the evaluation of: (1) the interaction of mission orientation, structure, and physical entities in Problem 1; and (2) survivability in Problem 2.

As indicated in Section E, several of the measures are functions of other, lower-level measures. The actual algorithm for any given application must be validated and verified against real world or other applicable observations. For the purpose of this thesis, the values of such proposed measures as FAIR, ${}^{X}MO_{Ti}$, ${}^{X}CS_{Ti}$, and C2/FE are defined as the weighted sum of the constituent MOPs. However, other weights are arbitrary and the relationships could be linear or non-linear, relational or multiplicative. Only replication, conferencing and/or synthesis of expert opinion, and external validation can present more certainty on the assessment of factors and their aggregations. The major advantage of this

thesis is that it broaches the subject and presents a strawman for consideration by the analytical community.[2]

2. V Corps Baseline

In evaluating the V Corps baseline it would be counterproductive to attempt to apply the quantitative standards used for the three operational capabilities. The baseline condition requires a subjective evaluation based upon the appropriate doctrinal publications and operational experience.

a. Problem 1

Before implementing the DCP concept, the commander and his staff were able to exercise command and control to meet mission objectives. Certainly the staff was as flexible, available, and responsive as their procedures and communications support allowed. On the other hand, traditional command posts had no links to other C2 systems, and the staff received all of their information by hard copy message, facsimile or verbal report. Although staff members may have prided themselves on their efficiency, they had no way to speed up the flow of critical information from its source(s) to the commander. In a similar manner, the staff had only a limited capacity to handle data, reports, or functions during a given period; they were often overcome by events during operations.

In analyzing the manual C2 process, it becomes obvious that technology would be hard pressed to meet the staff's contribution to the C2 functionality. However, the greatest potential of automated C2 systems lies in improving the physical entities' and structural components' contributions to overall C2 mission orientation.

---

[2] Conversation between Dr. Ricki Sweet, Sweet Associates, Ltd, and the author in San Jose, California, 11 March 1988.

b. Problem 2

The V Corps commander wanted to employ the DCP concept in 1981 to dramatically increase command survivability. (Appendix E describes the numerous threats to the corps command posts.) It was obvious at that time that merely dispersing the modules of the main CP would not be enough. A plan was required that would support continuity of operations with redundancy of functional staff personnel and key information. Before it implemented the DCP concept, V Corps had no way to consistently achieve command survivability.

c. Problem 3

The third problem cannot be fairly addressed with regards to V Corps' use of a consolidated main CP. Before dispersion, V Corps recognized the threats to command survivability and effectiveness but was constrained by Army doctrine and materiel in its efforts to improve the situation.

III. <u>OPERATIONAL CAPABILITY 1</u>

A. PROBLEM DEFINITION

The Defense Nuclear Agency started the first operational capability in September 1981 with a microcomputer workstation demonstration during REFORGER 81. The exploratory development program had proceeded from concept formulation to the initial design and demonstration phase. Designs and capabilities were tested and refined during the four exercises of Operational Capability 1 (OC1): REFORGER 81, Able Archer 81, Crested Eagle 82, and Caravan Guard III.

This section addresses four issues central to problem formulation:

1. What were the stated requirements of OC1?
2. What tasks from the statement of work (SOW) supported OC1?
3. What design principles, mandated by DNA, guided the development?
4. What were the goals of each exercise?

Figure 3.1 shows the five requirements of OC1 along a month by month timeline consisting of 17 months. The dates of the four exercises during OC1 are marked by "•," and are listed below the central rectangle. The objectives of OC1, based upon the requirements and the technological characteristics, are shown to the right.

1. <u>Requirements for OC1</u>

OC1 objectives consisted of: (1) the effective implementation and operation of nine dispersed V Corps command post modules, (2) distributed processing through an automated communications gateway, (3) automated briefing files, (4) an electronic mail system, and (5) initiation of a divisional SPADS system.

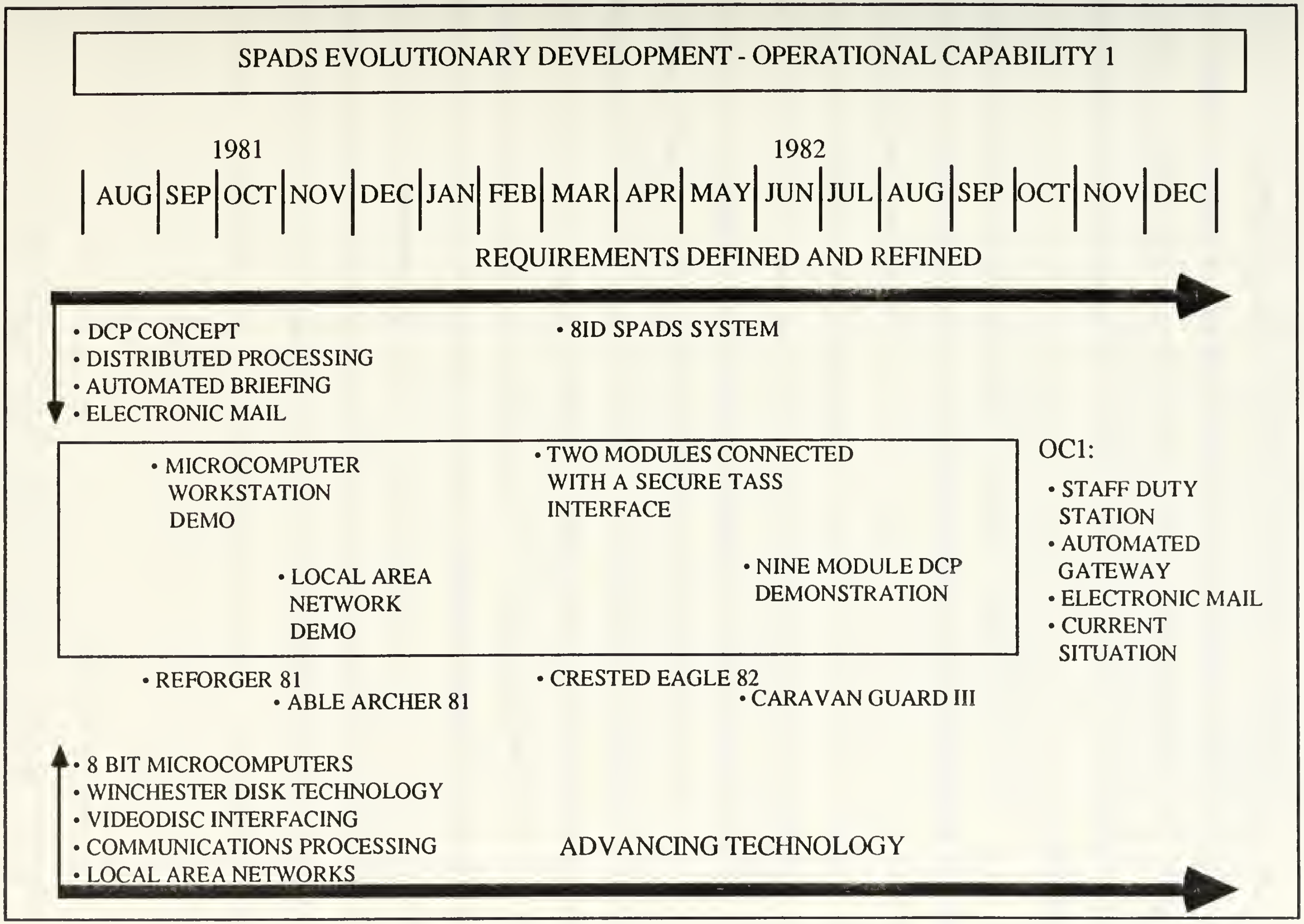

Figure 3.1. Overview of Operational Capability 1

a. V Corps DCP Concept

The DCP experimentation program was conducted under Contract DNA001-81-C-0277[1], awarded in August 1981. The purpose of the contract was to allow the earliest possible testing of the V Corps DCP concept. To accomplish rapid fielding, DNA employed non-developmental items (NDI) which took advantage of off-the-shelf technology.

DNA established a testbed at V Corps; its objective was to develop an automated command and control system instrumental to testing and evaluating the dispersed command post concept. The primary test objective—evaluating the effectiveness of the DCP concept—would be accomplished while responding to the V Corps request of May 1981 [Ref. 4:pp. 1-2]. What remained was to design an automated C2 system which could be fielded rapidly to support the test and evaluation of the DCP concept.

DNA postulated a DCP model which called for the fragmentation of the corps main command post, particularly the Tactical Operations Center (TOC), into several modules and for dispersal of these modules with ten kilometers or more between them. DNA envisioned that the concept would be extended throughout the corps operational area to its supporting CPs such as the Rear Area Operations Center (RAOC) and the tactical command post (TAC CP), as well as to combat divisions and armored cavalry regiment. After action or lessons learned reports would be prepared for each exercise conducted during this operational capability period (August 1981 through December 1983). [Ref. 8:pp. 9 -13]

---

[1] Interview between R. Laird, Lieutenant Colonel, USA, Defense Nuclear Agency, Alexandria, Virginia, and the author, 17-18 December 1987.

Since requirements were expected to be refined as the system was fielded and experimentation proceeded, an evolutionary development approach and modular design philosophy was adopted [Ref. 8:pp. 75-9]. This would allow early fielding of basic capabilities and subsequent DCP experiments, while providing the flexibility to add greater and more finely tuned capabilities throughout the test period. It would also allow the experiment to proceed without waiting for the availability of microcomputer and peripheral equipment based on emerging technologies, and it would maintain the ability to insert advanced capabilities when those technologies matured and new equipment was available in the commercial marketplace.

b. Distributed Processing

The V Corps automated prototype was required to support a distributed processing configuration consisting of a network of microcomputer workstations. (This definition contrasted with traditional automated systems composed of one central processor and dependent terminals that are incapable of independent processing.) A local area network (LAN) would connect workstations within each V Corps command post module. A communications gateway would provide network connectivity via Army voice communications channels. The supporting architecture would include a replicated data base at each module, thus providing each cell with the same information. The communications links between and among the modules were to be provided by the Tactical Area Switching System (TASS). The capabilities at each work station would eventually include word processing, electronic mail, graphics and overlays, a relational database management system, map and photo correlation, spreadsheet models, and functional area algorithms. [Ref. 8:pp. 36-38]

c. Automated Briefing

An automated briefing capability was specified to enable any staff officer to create briefing slides and text at a workstation. In order to minimize communication requirements when transmitting these briefing slides to other modules, graphics information that was not expected to change would be created and stored as a background slide. Information that was expected to change would be created, stored, transmitted, and presented as an overlay. All slides would be stored on a module's mass storage station. New and updated slides from other modules were to be received through the communications gateway and stored at the mass storage station. A printing capability for text and graphics would be provided. [Ref. 8:p. 26]

d. Electronic Mail

An electronic mail system (EMS) was required to transmit messages between the workstations in the dispersed modules of the DCP. The EMS would be able to handle standard text messages as well as non-text material such as graphics. Mail would be prepared by the operator and would be sent to any other user through that module's gateway. [Ref. 8:p. 27]

e. 8ID DCP Concept

The 8th Infantry Division would be employed as a smaller and more tactical version of the V Corps testbed. The requirement was to provide dispersal plus effectiveness for the small, highly mobile elements of the division command posts.

2. Tasks from the Statement of Work

a. Task 1: V Corps Support

This task provided for support to V Corps during Exercises REFORGER 81, Able Archer 81, and Crested Eagle 82. The first responsibility was to ensure that the current procedures, SOPs, reports, and information flow were examined before proceeding

with the project. The second responsibility was to gather specific requirements from the principal staff sections so that applications and data bases could be developed.

b. Task 2: DCP Concepts

The purpose of this task was to identify and test feasible information exchange concepts for the DCP project. For communications networking within the module, different commercial LANs would be tested and one selected to support SPADS. For communications networking between modules, gateway concepts would be examined and tested to determine the baseline for developing a communications gateway that could support the DCP concept. All networking tests would be conducted in CONUS.

c. Task 3: Caravan Guard Support

This task specified various tasks to support the V Corps DCP concept in Germany. The staff operators, NCOs, and action officers would be trained on how to use SPADS to support V Corps DCP operations. An SOP would be developed for dispersed operations that used microcomputer equipment. Communications gateway software development would proceed to support four dispersed CP locations.

d. Task 4: PTT Management Interfaces/Procedures

This task required that the West German national telecommunications system (the Deutsches Bundespost, or DBP) be examined to determine how it could support SPADS. The first test would determine whether gateways would be able to communicate over the standard DBP phone lines. This would be followed by tests to determine if special "conditioned" data links would be required to effectively use the DBP.

e. Task 5: V Corps/8ID C2 Doctrine Evaluation

This task would develop a capability to evaluate, through evolutionary testing, the effectiveness of the requirements for emerging Army doctrine on dispersed field C2. The principal effort would be to develop a testbed to evaluate an information

distribution and processing system between the corps, division, and corps/division command elements. The final test plan would provide a basis for documenting and evaluating the results of the theoretical efforts related to internal corps and division C2 operations.

Task 5 carried the V Corps DCP demonstration through the fall of 1982. In January 1982 the Army Communicative Technology Office (ACTO) provided $536,000 (of the $1.2 million required for SPADS up to that date) to purchase equipment for a "full-up" demonstration.[2] The pacing items would be software development and assimilation of the equipment by V Corps.

f. Task 8: 8ID AirLand Battle DCP Program

The purpose of this task was to develop a division-level SPADS program that would eventually be integrated into the V Corps DCP program. The sub-tasks were to: (1) deliver a division level SPADS system, (2) conduct user training for the 8ID, (3) support the user test of the system in garrison, and (4) support user tests of the SPADS system in the field environment. This task specifically required support for 8ID to develop and validate the operating procedures as well as to develop and test its own field procedures. The TRADOC Combined Arms Center contributed $480,000 in March 1982 to support the 8ID SPADS development.[3]

3. DNA Design Principles

The DNA evaluated necessary automated command and control requirements from the perspective of battlefield information needs and the capabilities available from commercial NDI technology. That analysis produced seven design principles and an ap-

---

[2] Ibid.

[3] Ibid.

proach to evaluating the DCP concept. This section addresses those design principles that were incorporated in OC1. [Ref. 8:p. 16]

a. Maintain a Common Battlefield Perception

Every module in the DCP had to share a common perception of the battlefield situation if operations were to be effectively planned, executed, and controlled. This meant that every module must have the same information. A key design concept of the DCP automated C2 system was replication of the essential parts of the current situation information available at every module. Each module was responsible for maintaining a portion of the Current Situation data base and transmitting updates to all other modules. The common perception concept would [Ref. 8:pp. 17-18]:

1. Allow the commander immediate access to critical data on the total situation at any module and at any time
2. Provide a common perception of all aspects of unit status to all corps modules
3. Provide redundancy necessary for continuity of operations
4. Be less dependent on the communications system than remote query to a central data base
5. Relieve the staff from the necessity of requesting critical information from other modules

b. Minimize Data Transmission

Limited Army tactical communications capabilities within the corps required a conservative data update philosophy to reduce the heavy burden that data, particularly data for graphics displays, could impose. The principle adopted for the DCP would be to transmit only overlay data through electrical means; backgrounds such as maps or chart matrices would be pre-positioned at all modules or delivered by courier. Only the data that changed (i.e., the overlays) would be sent through the communications network. [Ref. 8:p. 19]

c. Maintain Continuity of Operations

The critical requirement for continuity of operations influenced the DCP equipment configuration and recommended employment concept. The basic principle was to design for graceful degradation. If part of the system failed, the remaining components should continue to operate. Specific design features were [Ref. 8:p 21]:

1. Distributed, intelligent workstations would be selected rather than the traditional, less capable terminals serviced by a multi-user central computer
2. A graphics plotter would be employed at selected modules to periodically provide backup acetate overlays of the force status and enemy situation; this duplication would ensure that critical map overlays would be available even if the system totally failed
3. A medium-speed printer would provide hard copy text and ensure that essential records were kept in the event of a major system failure
4. A direct communications interface between selected workstations at distant modules would provide backup communications in the event of a gateway failure or during peak traffic backlogs
5. The data bases and current situation briefings would be duplicated at each module; each module would contain the data necessary to reconstitute the functions of a destroyed module

d. Computational Support

Each module would have its own set of requirements for analysis, e.g., generating spreadsheets on personnel and equipment needs, or for creating local data bases. The system would be designed to provide the capability of executing commercial software programs and creating local programs to meet the needs of each module. This principle would ensure maximum utilization of existing programs and enable individual staff elements to develop software tailored to their specific needs. [Ref. 8:p. 21]

e. Provide a Rugged, Low-cost System

The DCP program was required to use commercial equipment modified for field use. The time to develop and field the system was thus expected to be one-fifth of the normal development time because of the use of off-the-shelf commercial products. This

would also maintain a lower cost than conventionally developed hardware and software programs.

It would be necessary to take some steps, without attempting full militarization, to ensure that the hardware package would perform effectively in the field. The microcomputers would be modified to provide simple connections between the computer and other devices in the system. This would alleviate the need for an operator to open the microcomputer case to make connections in the field environment. Special transport cases would be designed to protect the equipment from exposure and during transportation. The rigid cases would provide the structural framework for the operating workstations. [Ref. 8:p. 21]

4. Exercise Objectives During OC1

The objective for Exercise REFORGER 81 was to demonstrate the capabilities of a microcomputer workstation in the corps main command post. The objective of the next exercise, Able Archer 81, was to demonstrate that files could be transferred over Army tactical communications between microcomputer workstations in different modules. The two objectives for Exercise Crested Eagle 82 were to: (1) conduct a test that demonstrated that bulk-encrypted data could be transferred between two modules using TASS, and (2) to add the 8ID to the DCP experiment. The five objectives of the last exercise, Caravan Guard III—the most significant of OC1—were to: (1) simulate the dispersal of nine modules, (2) use the automated communications gateway station (CGS) over TASS, (3) connect the 8ID main CP to the corps SPADS system, (4) disperse the TAC CP up to 45 kilometers from the main CP, and (5) implement the Current Situation and Electronic Mail System (EMS) software. Table 6 presents the exercises and objectives of OC1. [Ref. 8:pp. 26-28]

TABLE 6

OVERVIEW OF OPERATIONAL CAPABILITY 1

	Primary Objective(s)	Date
Contract Award		Aug. 1981
Exercise REFORGER 81	Demonstrate microcomputer workstation	Sept. 1981
Exercise Able Archer 81	Demonstrate file transfer	Jan. 1982
Exercise Crested Eagle 82	Transfer bulk-encrypted data between two modules	March 1982
Exercise Caravan Guard III	Disperse nine CP modules Automate communications gateway over TASS Add 8th Infantry Division to experiment Disperse CP modules up to 45 km apart Test Current Situation and Electronic Mail System	June 1982

B. BOUNDING THE C2 SYSTEM

This section addresses the bounds of the SPADS system in terms of physical entities and structure at three distinct levels. First, the workstation bounds the hardware and software with which an operator interacts. Next, the module level describes the SPADS entities and structure within the confines of one modular command post. Finally, the network level defines the SPADS system within the geographical and hierarchical bounds that interconnect the modules.

1. Workstation Level Bounding

a. Hardware

The only hardware that the staff officer or SPADS operator interacted with personally was the staff duty station (SDS). The SDS was contained in two ruggedized cases that stacked one atop another to provide an operational workstation. The upper case

contained two monitors. The lower case contained an Apple [4] II+ microcomputer, two floppy diskette drives, and a power control panel. The Apple II+ microcomputer was the central focus of the SDS. Inside the microcomputer case were numerous interface cards to control the disk drives, provide accurate time, interface with the printer, provide a serial port for a modem, and provide extra random access memory (RAM). The operator typed all commands at the keyboard. Two 5-1/4-inch floppy diskette drives were attached to the backplane of the microcomputer. These drives could be used to store and input data or to execute commercial software programs. On the left side of the upper SDS case a black and green (B&G) monitor provided for text display. To the right, an analog color monitor displayed briefing slides. Table 7 presents an overview of the SDS hardware. [Ref. 8:pp. 38-41]

b. Software

All SPADS software functions were performed at the SDS by the operator. The two required functions implemented during OC1 were Current Situation and Electronic Mail System (EMS). Current Situation provided an immediate overview of the battle situation, including the status of units. It was dependent upon the Briefing package, which provided the ability to create and present briefings. EMS allowed the operator to send or receive standard text messages, data, graphics, and computer code. One flexible SPADS software package was Local Program Execution, which allowed the operator to execute programs locally, e.g., special programs to assess personnel needs, logistics support, and other staff tasks. [Ref. 8:pp. 44, 48]

---

[4] Apple is a registered trademark of Apple Computer, Inc., Cupertino, California.

TABLE 7
STAFF DUTY STATION HARDWARE

Microcomputer	Apple II+
Processor	Synertek MOS 6502, 8-bit data
Memory	48K (64K with Slot 0 Card)
Graphics	5 x 7 Dot matrix for 280 x 192 array
Monitors	Analog Color Display Black and Green Display
Keyboard	52-key typewriter keyboard (attached)
8 Slot Expandable Bus	
Power supply	120V/50-60 Hz power
Floppy Drive (2)	5-1/4-inch, 140 Kbytes

The Current Situation package preceded any common data base function in SPADS. Current Situation allowed text and slide displays of any data that the staff wished to include. Current Situation data consisted of input from local users plus information obtained from staff sections in other modules. All information generated or received was stored on the module's mass storage station. All locally generated slides and text used in Current Situation were transmitted through the CGS to the other command post modules. Any operator was able to obtain a hard copy printout of the text and graphics information from the shared output station. [Ref. 8:p. 48]

The operator was able to create briefing slides and text at the SDS. In order to minimize communications requirements when transmitting slides to other modules, graphics information that was not expected to change from one slide to another was created as a background slide. Information that was expected to change was presented as an overlay. When updates were needed to a given set of slides, only the overlays had to be

transmitted. The text provided with the slides described the essential features of the displayed graphics information. [Ref. 8:p. 56]

EMS was the principal mechanism for transmitting messages between the modules of the DCP. EMS handled all standard text messages as well as non-text material such as graphics. Outgoing mail was prepared at the SDS by the operator. Incoming and outgoing mail was handled by the gateway. All mail was stored in "mailboxes" on the hard disk of the mass storage station. The mail could be called up for reading by addressees, sent to the shared output station for printing, or both. [Ref. 8:p. 51]

2. Module Level Bounding

A SPADS module consisted of one or more staff duty stations, a mass storage station, a shared output station, and a communications gateway station, all interconnected by a local area network. Table 8 presents a summary of the module-level hardware and communications capabilities.

The mass storage station (MSS) was the primary shared memory for the SPADS module. It normally contained all of the data, text, graphics, and computer programs for each module. The MSS consisted of a hard disk drive, a hard disk server, and a videocassette recorder (VCR). The server controlled access to the hard disk and its operations. These included local work files used by each SDS as well as common data base files. The VCR was used to create a backup copy of the hard disk. Only one MSS was installed at each module.

The shared output station (SOS) provided medium-speed, medium-volume printing and plotting capability to support the module's SDS operators. An SOS consisted of an SDS, a printer,and an optional plotter. Some modules had a plotter capable of producing large map overlays, hard copy slides, and conventional hard copy paper plots. All the SDSs in a module had access to the SOS for their printing and plotting needs. The

SOS was essential for module operations during OC1 because the SDSs did not have local printers available. [Ref. 8:p. 44]

TABLE 8
MODULE-LEVEL HARDWARE AND COMMUNICATIONS CAPABILITIES

Gateway Microcomputer:

- Apple II+ (four required/gateway)
  - Synertek MOS 6502
  - 48K (Expanded to 128K)
  - 5 X 7 Dot matrix for 280 x 192 array
  - 120V/50-60 Hz power

Corvus[a] 20 Megabyte Hard Disk:

- Winchester technology
- 64 device capable common bus
- 1000 foot trunk length
- Non-collision network

Communication Hardware:

- Multichannel—TRC 151/145
  - Bulk encryption—KG-27
  - 300—1200 baud
- TASS switching—TTC 38/41
- PTT-KG-84: 300—1200 baud

Software Capabilities:

- Variable packet size
- RS 232/RS 422 protocols
- Error detection code
- Corvus Constellation protocol

The communications gateway station (CGS) was the link between each SPADS module and all the other cells in the DCP. It was mandatory for module operation. The CGS consisted of three Apple II+ microcomputers, up to four modems, and two B&G monitors. Its purpose was to process incoming information, control the transmission of

---

[a] Corvus is a registered trademark of Corvus Computers, San Jose, California.

outgoing information and maintain the EMS network control. Figure 3.2 presents a schematic of the Apple II+ Communications Gateway Station. [Ref. 8:p. 44]

3. Network Level Bounding

The DCP consisted of a network of SPADS modules with one gateway per corps command post module. In the initial distributed command and control network, the CGSs were connected via the Army Tactical Area Switching System over tactical multichannel radios or cable systems. [Ref. 8:pp. 28-30]

C. C2 SYSTEM ARCHITECTURE

1. Workstation Level Integration

Once V Corps had working staff duty stations in its modules, the staff began to implement manual functions either through provided SPADS software or through local program execution. Chapter II presented an overview of the functions of the corps commander and staff in any CP configuration. (Appendix E provides an in-depth look at the tasks that must be performed by the corps staff.) Even before SPADS was being formalized in procedures and SOPs, resourceful staff personnel were using SPADS to perform more effectively.

The next four figures present the integration of each software package with the C2 system and the C2 process. First, Figure 3.3 displays the integration of system, process, and function with Current Situation [Ref. 8:pp. 48-49], then Figure 3.4 shows the integration of entities, structure, and functions with Briefing [Ref. 8:pp. 56-57]. Next, Figure 3.5 illustrates the integration of Electronic Mail System with the processes, structures and entities [Ref. 8:pp. 51-52]. Finally, Figure 3.6 depicts the integration of system elements and functions with Local Program Execution [Ref. 8:pp. 44, 48, 62].

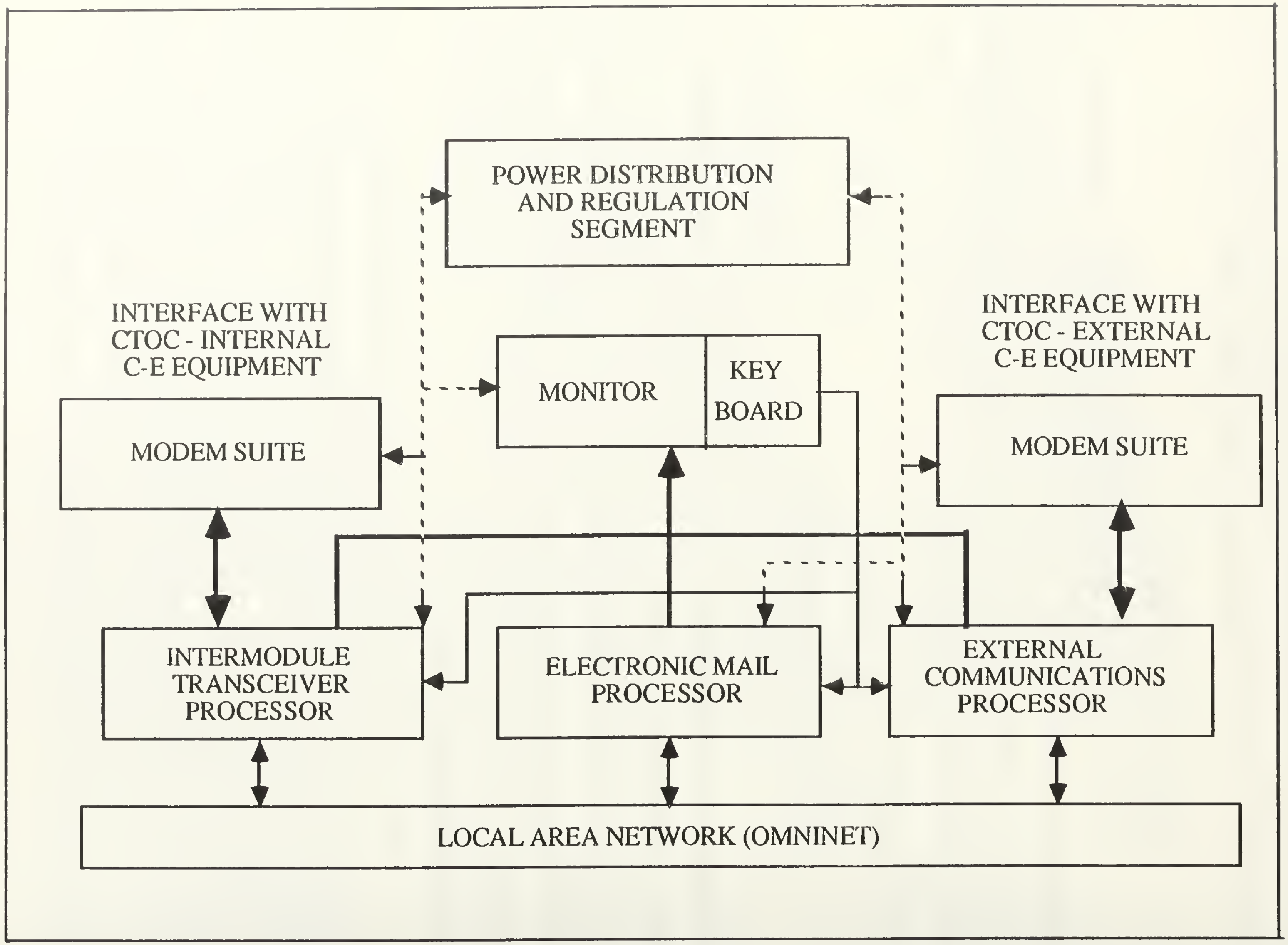

Figure 3.2. **Schematic of Apple II+ Communications Gateway**

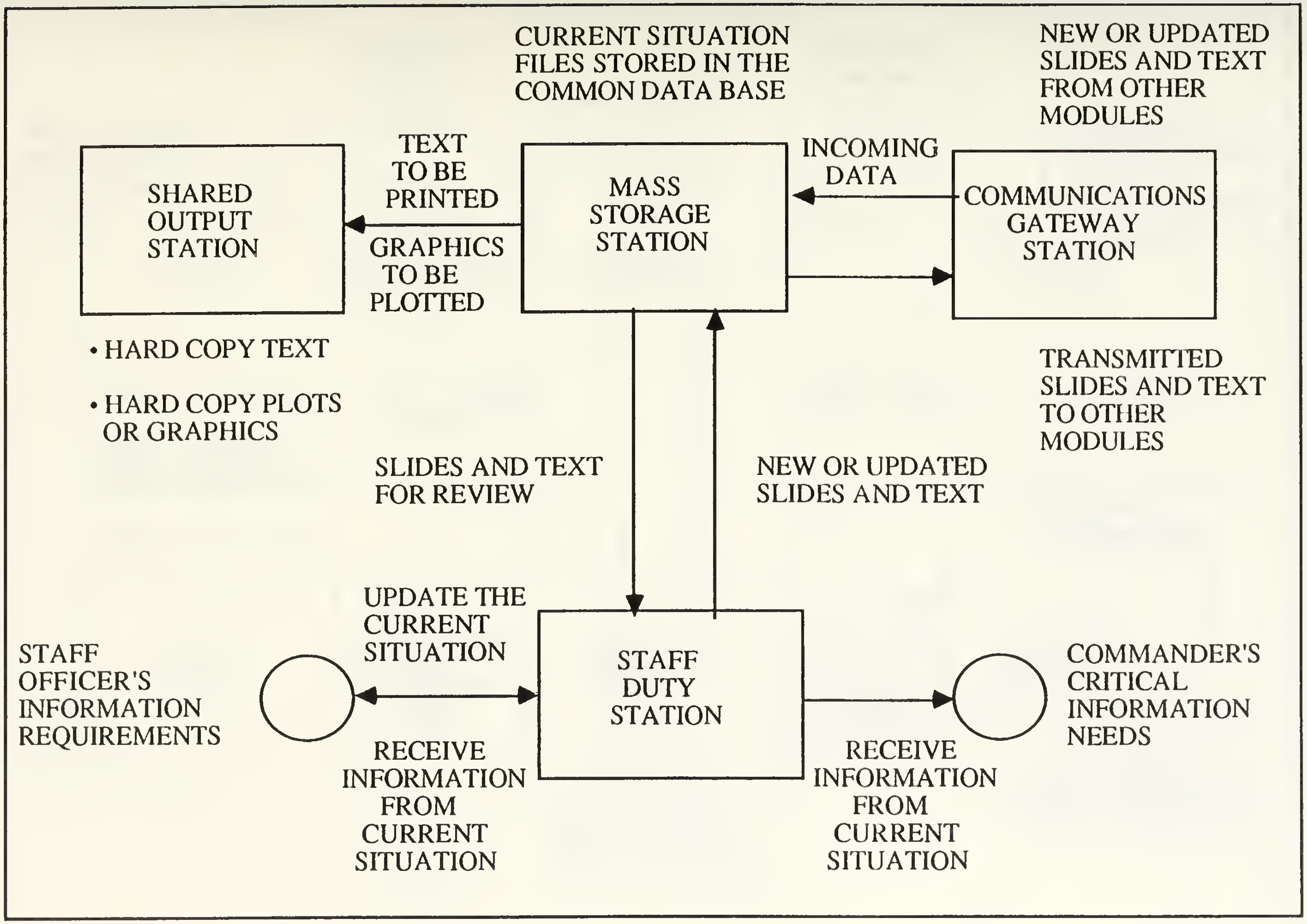

Figure 3.3. Integration of the Current Situation

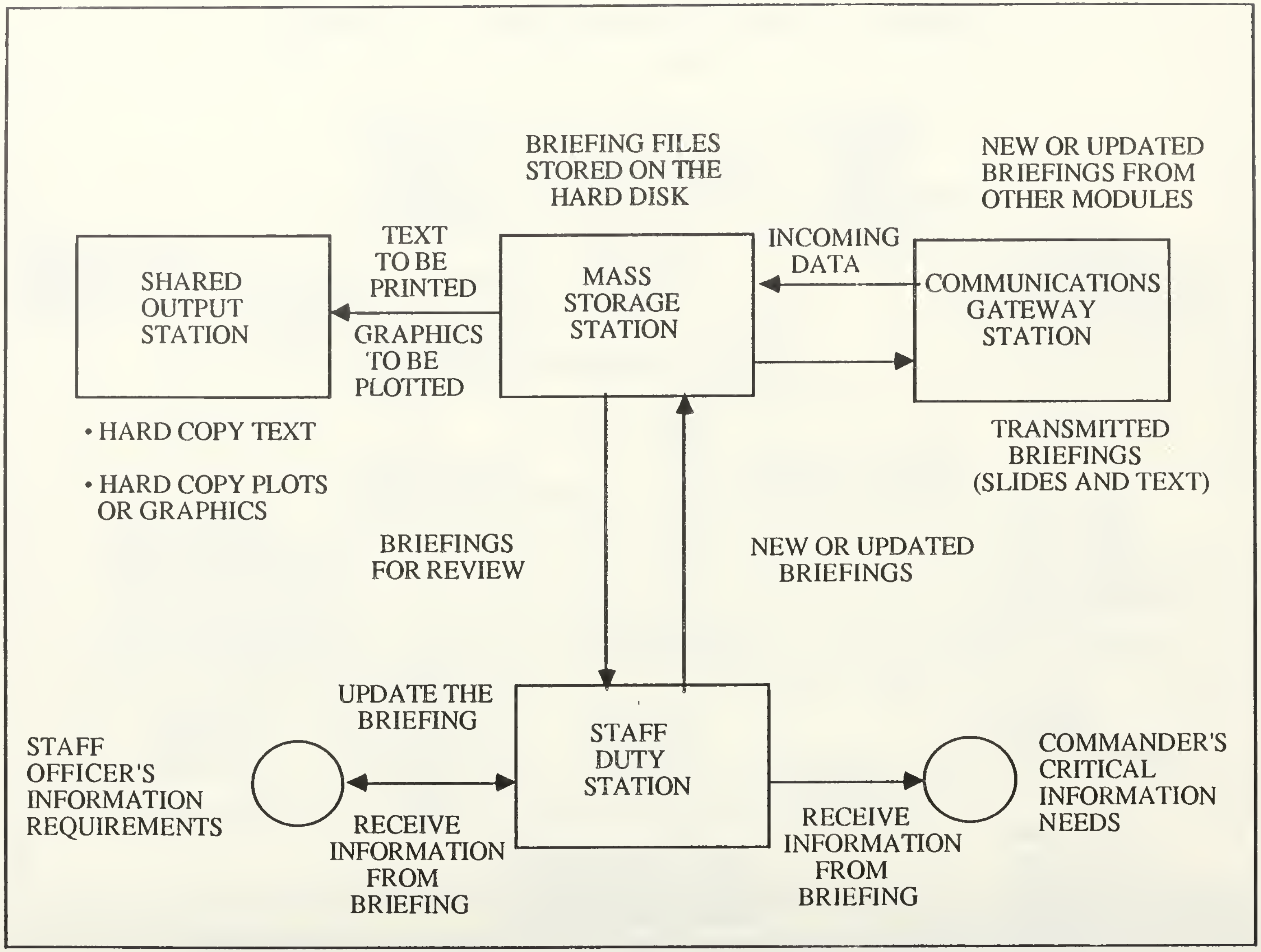

Figure 3.4. Integration of the Briefing

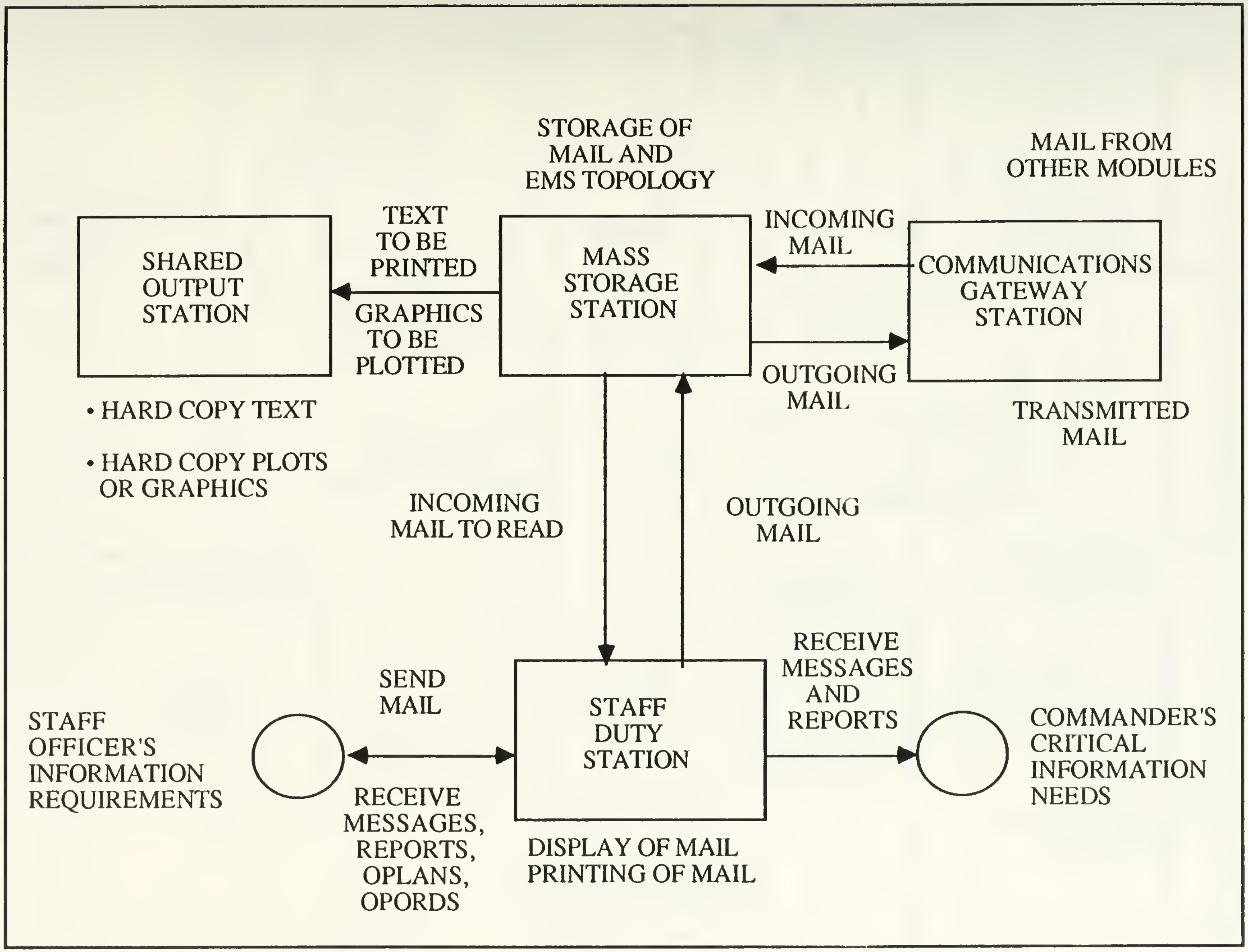

Figure 3.5. Integration of Electronic Mail System

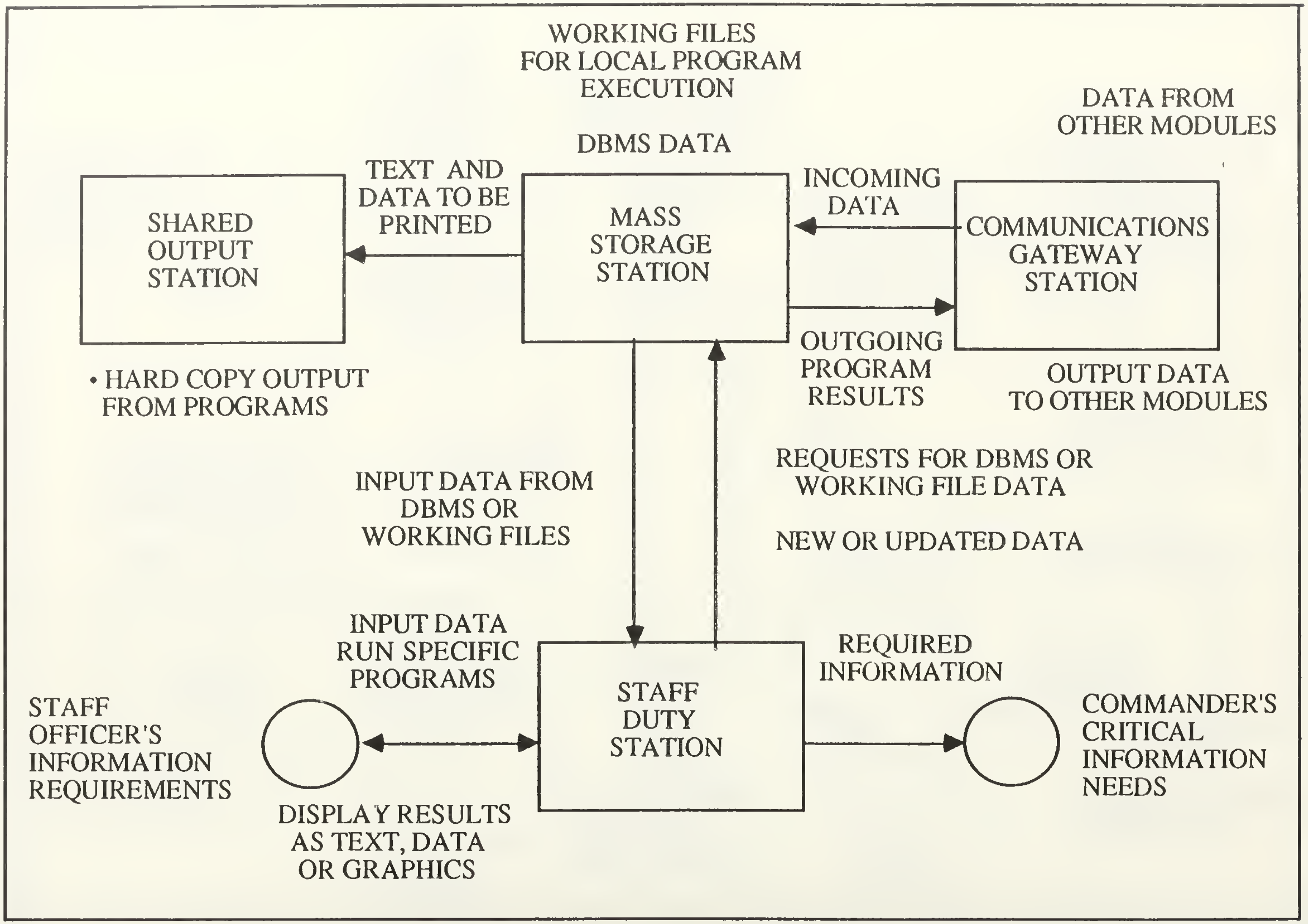

Figure 3.6. Integration of Local Program Execution

2. Module Level Integration

Throughout OC1 the addition of SPADS hardware and software was slowly influencing the structure, organization, procedures, and information flow patterns of the V Corps command posts. In comparison to Chapter II's pre-DCP architecture, Figure 3.7 presents module-level integration within a generic module during OC1.

3. Network Level Architecture

The most significant integration at the network level in OC1 occurred during the period that covered Crested Eagle 82 and Caravan Guard III. In March, during Exercise Crested Eagle 82, two corps modules were physically dispersed and transmitted files between them. Furthermore, during Exercise Caravan Guard III in June 1982, nine modules of the V Corps DCP concept were used and SPADS links were established between four dispersed modules. In addition, the 8ID main CP was connected to the V Corps main CP through SPADS at a distance of almost 40 kilometers.

Once the corps was able to support the DCP concept through SPADS communications gateway stations, it was in a position to begin integration of the V Corps C2 process from the individual staff duty stations throughout the entire network.

D. DATA GENERATION

The data generated for this OC are shown in Table 9[5] . The data generation worksheet and formulas discussed in Chapter II were used to produce values for this OC. The means for each evaluation category are displayed in Figure 3.8. A brief review of the data generation procedures—presented in Chapter II—follows in the next paragraph.

---

[5] The following sources provided raw data on these exercises: Reference (REFORGER 81, Able Archer 81, Crested Eagle 82, Caravan Guard III), Reference 10 (Caravan Guard III), Reference 11 (Caravan Guard III), and Reference 12 (Caravan Guard III).

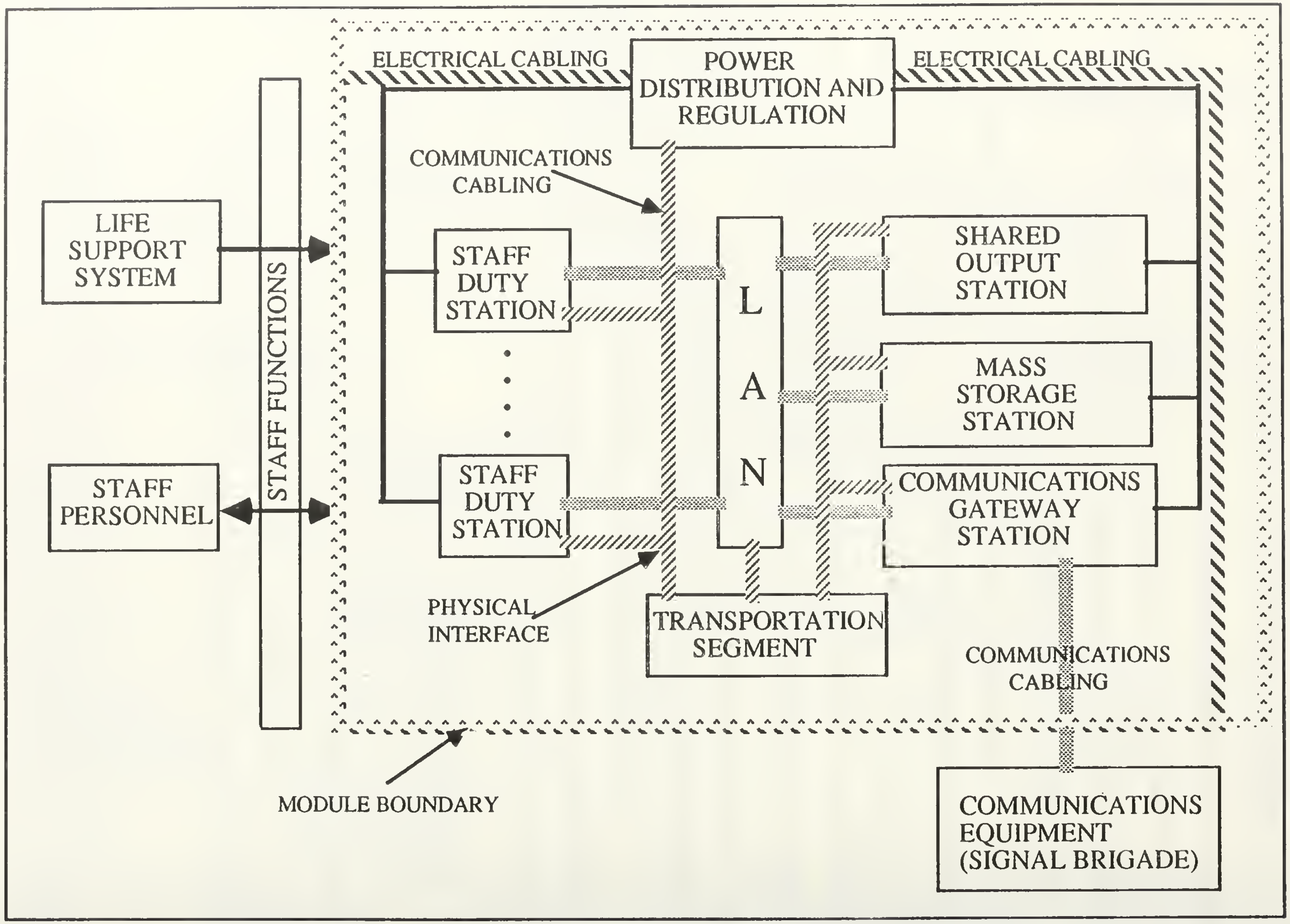

Figure 3.7. Integration at the Module Level in Operational Capability 1

TABLE 9
DATA GENERATED FOR EACH EXERCISE DURING OC1

Measurement Categories	REFORGER 81	Able Archer 81	Crested Eagle 82	Caravan Guard III
FAIR	3	6	12	22
Timeliness	0	0	0	0
Capacity	1	1	2	8
XMOTi	**4**	**7**	**14**	**30**
Dispersion	0	0	0	8
Redundancy	0	0	0	0
Continuity of Operations	1	1	2	6
XCSTi	**1**	**1**	**2**	**14**
C2/FE	**5**	**8**	**16**	**44**

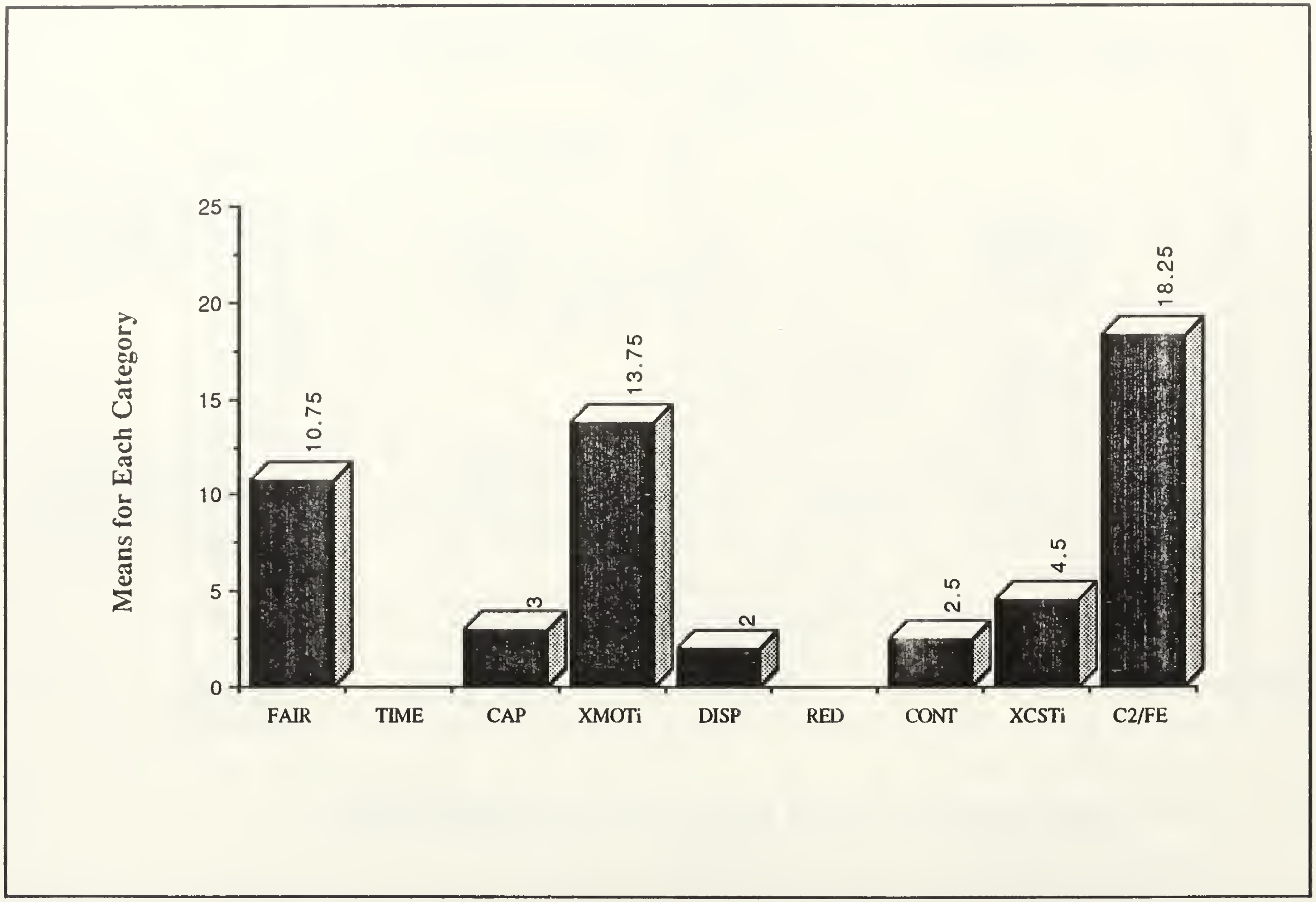

Figure 3.8. Means for Each Category During OC1

After action and lessons learned reports were collected from V Corps, DNA, and the developer for each exercise during this operational capability cycle. Using the worksheet, definitions, and procedures specified in Chapter II, values were determined for each measure from every exercise. The measures were individually considered as binary conditions for each DCP module that participated in the exercise. The summed measures (e.g., FAIR, XMOTi, and XCSTi) received their cumulative, unweighted scores based upon their constituent measures of performance or effectiveness. The final measure, C2/FE, was computed as a linear function of XMOTi and XCSTi and recorded on the worksheet. The results for each exercise are displayed in Table 9, and the means for each category are presented in Figure 3.8.

The reader should exercise caution in interpreting the values generated for OC1. The scarcity of data and the biases noted in Chapter II lead to a necessarily conservative view of the accomplishments of the V Corps DCP program during this 17-month period.

E. AGGREGATION AND INTERPRETATION OF MEASURES

1. C2 Mission Orientation

The value of C2 mission orientation, XMOTi, rises dramatically during OC1. This may be a gain in effectiveness; however, it may also represent the natural reaction to coping with the dispersed command post environment. The following subsections interpret the three components of C2 Mission Orientation.

a. C2 Process

There was a dramatic loss in functionality during OC1, and SPADS could have been exploited to regain the level of functionality that existed before dispersal[Ref. 12: pp 21-22]. While the functions of the V Corps commander and staff remained constant, the environment they had to work in changed drastically. The rise in FAIR represents the increasing functionality of the SPADS system within the DCP environment.

b. Physical Entities

The physical entities of the V Corps C2 system changed the most during this period. As the facilities were dispersed, new hardware and software was introduced to increase command survivability and bring C2 mission orientation up to its pre-dispersal level. The value of capacity remained constant for each module that was added to the DCP, but the total aggregated value increased as the modules were networked by the gateway and through TASS to one another.

c. Structural Components

The value of the structural measure remained at zero throughout OC1. SPADS was not able to accomplish the transmission of *critical information required by the commander* during this period. During each exercise more traffic was generated than in previous ones, but at no time could the V Corps commander depend on SPADS for critical decision making information.

2. Command Survivability

SPADS was able to make significant gains towards achieving command survivability during OC1. Dispersion between modules gradually increased from zero up to 48 kilometers—well beyond the minimum ten kilometers required. On the other hand, no progress at all was made toward redundancy; this specifically related to command influence and staff interest. Previous Army C2 systems and research studies indicated that if the commander did not provide personal leadership and demand use of the system, then the staff members would only use it in a haphazard manner. [Ref. 13:pp. 2-8 – 2-11, 2-39 – 2-42] Finally, the values of reliability remain constant throughout OC1, while the value for transportability rises to a steady level by Exercise Caravan Guard III.

3. C2 Force Effectiveness

SPADS clearly evolved during OC1 based upon the operational lessons learned. However, it is not clear that it evolved as a C2 force effectiveness system during this 17-month period. The evolution involved hardware, software, protocols, and communications interfaces. SPADS had not affected the organization, procedures, or concept of operations for the V Corps command posts. The dramatic rise in the value of C2/FE is directly related to the increase of XMOTi during the period; more specifically, it is related to the values of FAIR which measure the interactions of the C2 process. The measure of the structural component remains zero throughout OC1; therefore, it must be stated that C2/FE does not "evolve" during this period.

Figure 3.9 provides the cumulative (unweighted) value of each evaluation category for each exercise of OC1. Figure 3.10 displays the increasing value of each measure—XMOTi, XCSTi, C2/FE—throughout each exercise of the first operational capability.

F. SUMMARY

A basic workstation concept was demonstrated in Exercise REFORGER 81 during the month following contract award. By Exercise Crested Eagle 82, the SPADS concept was being verified with two modules passing data over encrypted TASS circuits. The experiment was accelerated with the deployment of nine modules in Exercise Caravan Guard III in June 1982. The V Corps rear, RAOC, and TAC CP modules were dispersed some 19 to 45 kilometers from the main CP and a connection was made to the 8ID main CP SPADS system at a distance of 48 kilometers. The main CP itself was broken up into five modules with dispersion *simulated* by distances of 100 to 400 meters between modules.

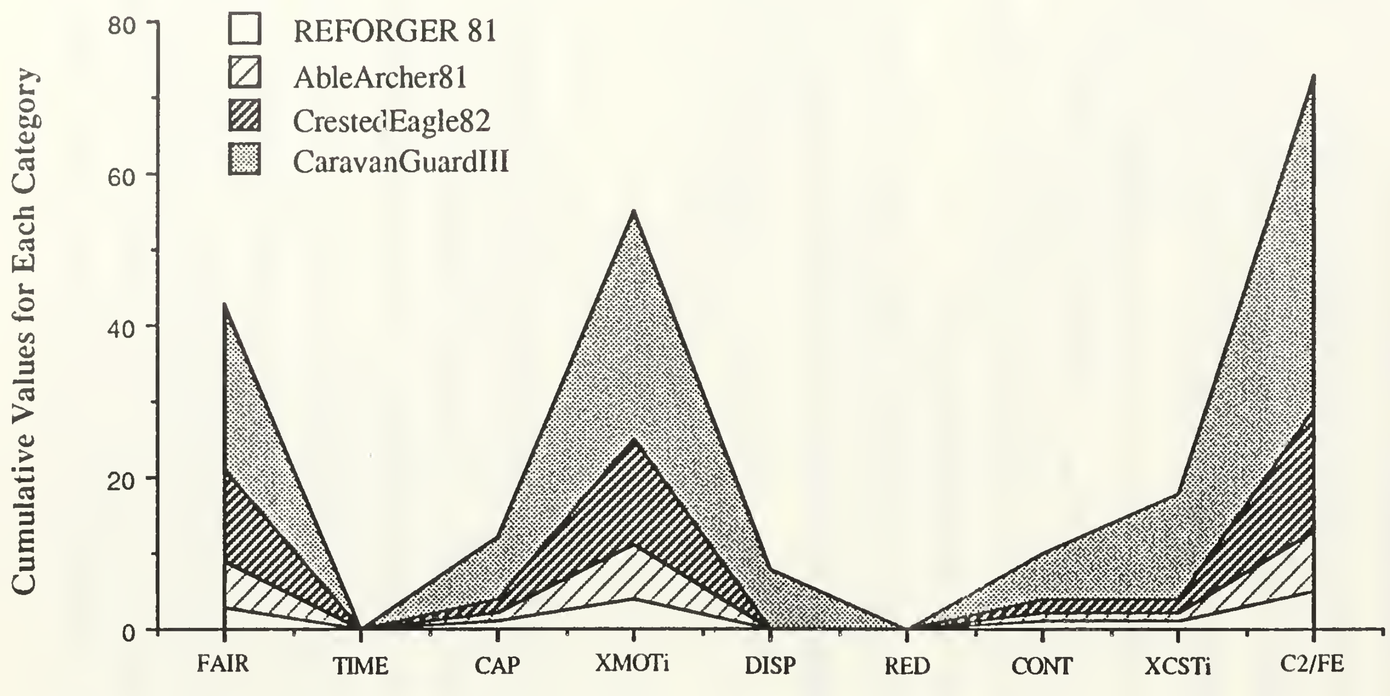

Figure 3.9. Evaluations of the Three Problems for OC1

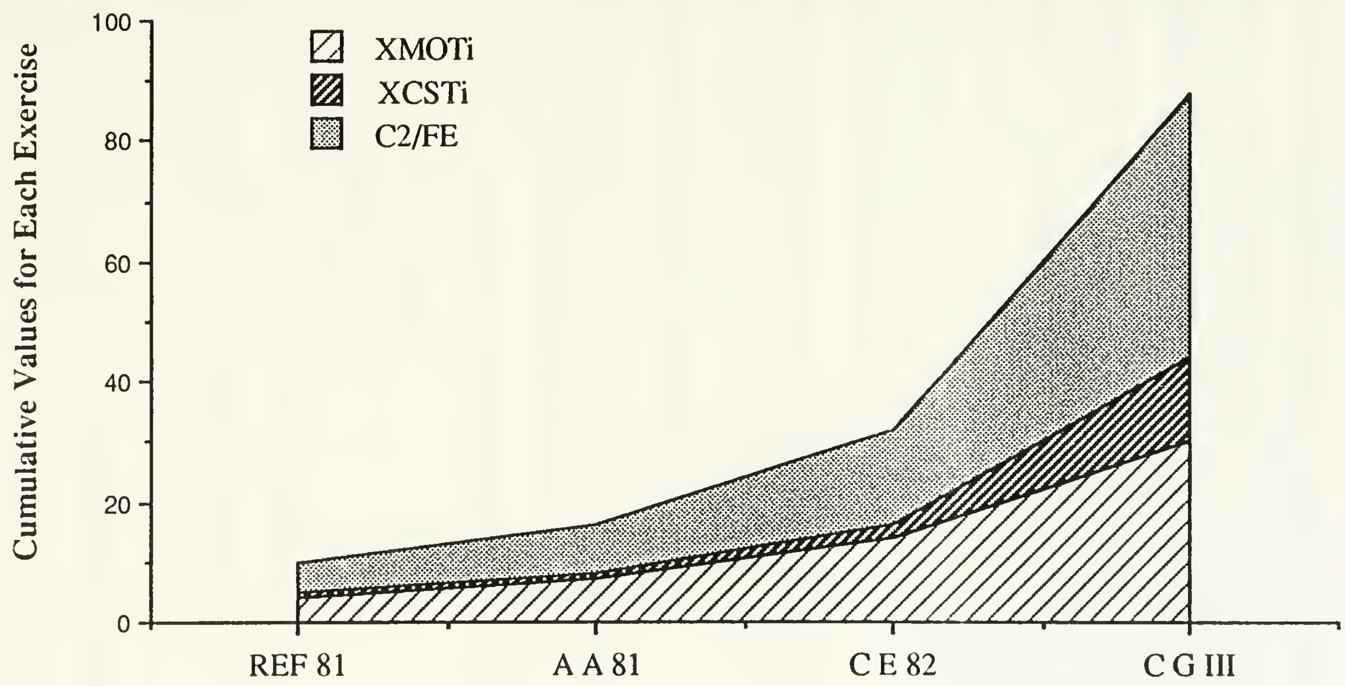

Figure 3.10. Comparisons of the Three Measures for OC1

The rapid deployment of equipment, the limited training time allocated to the staff and operators, and the lack of command influence and staff interest resulted in a mediocre demonstration of the SPADS system's ability to effectively support a dispersed command post. Nor was SPADS able to obviously enhance the commander's ability to achieve mission objectives during this period. However, the DCP concept had shown that it could be technically viable if SPADS equipment, software, procedures, and interface could be improved during the next OC. The key to success for SPADS would have been the direct influence of the commander, and the role the staff took in integrating SPADS into the entire V Corps C2 system [Ref. 13:pp. 2-39 - 2-42].

IV. OPERATIONAL CAPABILITY 2

A. PROBLEM DEFINITION

The second operational capability (OC2) began field testing in September during REFORGER 82. OC2 was planned and designed to use OC1 as a baseline condition and progress from there. Once again, designs and capabilities were tested and refined during the operational capability's four exercises: REFORGER 82, Able Archer 82, Wintex 83, and Caravan Guard IV.

This section addresses four issues central to problem formulation:

1. What were the stated requirements of OC2?
2. What tasks from the statement of work (SOW) supported OC2?
3. What other design principles, mandated by DNA, guided the development?
4. What were the goals of each exercise?

Figure 4.1 shows the seven requirements of OC2 along a month by month timeline. The dates of the four exercises during OC2 are marked by "•," and are listed below the central rectangle. The objectives of OC2, based upon requirements and technological characteristics, are shown to the right.

1. Requirements for OC2

The seven OC2 objectives to be completed during the 19-month period were: (1) development of videodisc-generated maps and overlays, (2) distributed and replicated data bases, (3) minimized data transmission with automated reporting capabilities, (4) development of a 16-bit microprocessor communications gateway station, (5) dispersal and effective operation of 13 modules in the V Corps DCP concept, (6) full implementation of

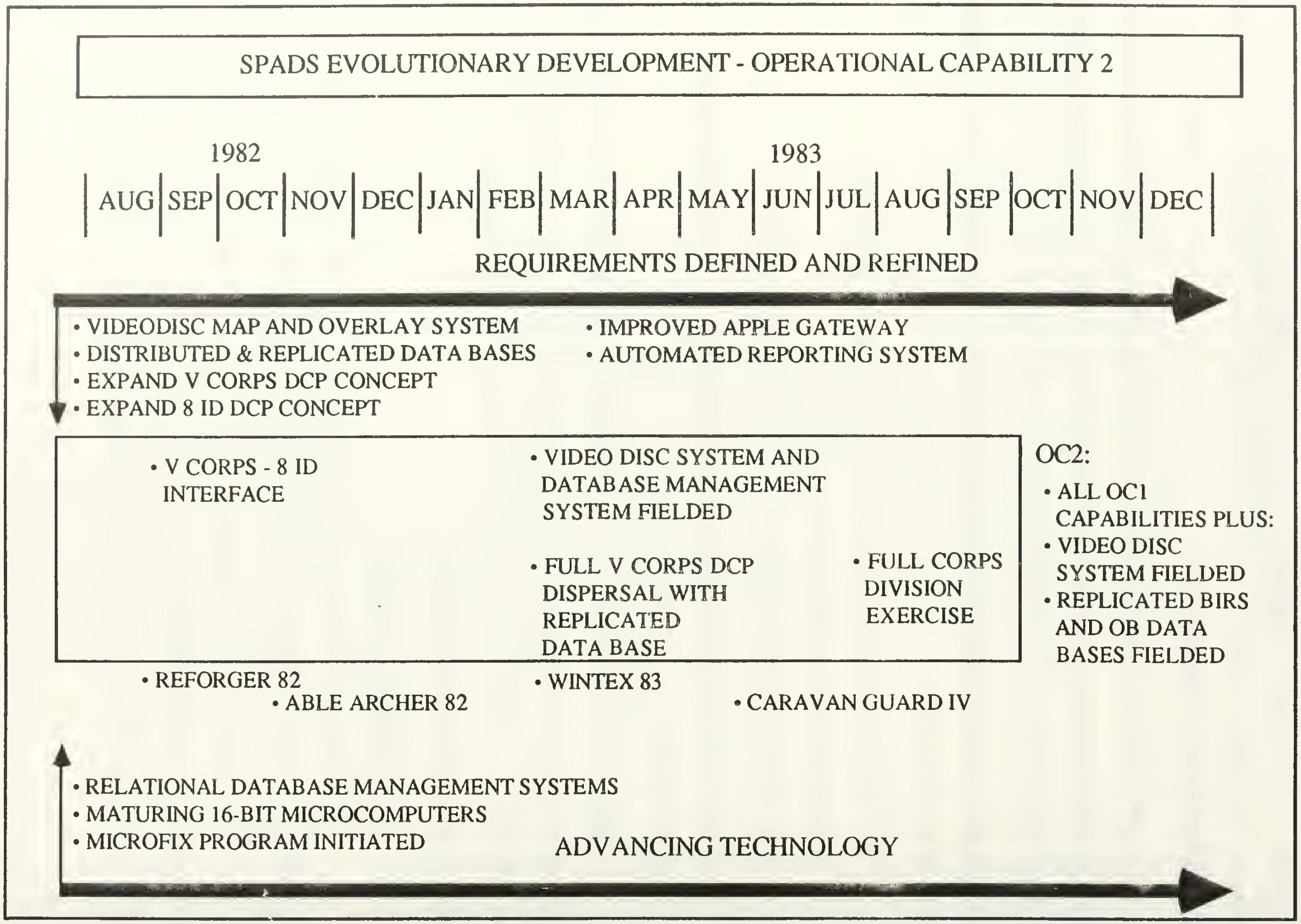

Figure 4.1. Overview of Operational Capability 2

the 8ID DCP concept, and (7) fielding of an improved Apple communications gateway station.

a. Videodisc-generated Maps and Overlays

OC2 specified videodisc-generated map and overlay capabilities that used standard map images and overlays of military symbols or icons. The maps were to be stored on videodisc. To minimize data transmission, only overlay images were to be sent electronically. [Ref. 8:pp. 32-33]

b. Distributed and Replicated Data Bases

The DBMS was to provide the basic capability for an operator to extract information from the data base and to enter new or update information. The SPADS DBMS was to provide the staff with a flexible, responsive and powerful data base. Two data bases were scheduled to be delivered at the beginning of OC2: the Battlefield Information Reporting System (BIRS), and the Order of Battle (OB). The BIRS data base was to be constructed to store friendly force data; the OB data base would provide storage for enemy force information. These were to be replicated data bases that would be updated throughout the SPADS network, and all SDSs would be able to obtain the same current information from their local module's hard disk. [Ref. 8:pp. 32-33]

c. Minimized Data Transmission with Automated Reporting Capabilities

Automated reporting capabilities were to be designed so that only data (and not the report format) would be transmitted electronically. This requirement was similar to the capability achieved in OC1 where only graphics overlays were transmitted. [Ref. 8:p. 32]

d. 16-bit Microprocessor Communications Gateway Station Development

This requirement marked a technological enhancement in the gateway function. The CGSs were taxed to their limits during full-up tests of the DCP. Therefore, a newer generation microcomputer with 16- and 32-bit architecture was to be selected to increase the speed of message traffic transmission and reception. [Ref. 8:p. 33]

e. Dispersal and Effective Operation of 13 Modules in the V Corps DCP Concept

The DCP experimentation program was to continue until the entire V Corps command post structure could be fully dispersed while effectively performing all corps battle tasks. This phase of the program was to progress from the accomplishments of OC1. Full dispersal would be conducted in parallel with the refinement of SPADS system requirements and the technological enhancements necessary to meet all of the OC's objectives.

After action or lessons learned reports would be prepared for each exercise conducted during the time period of this operational capability (June 1982 through December 1983). [Ref. 8:pp. 28-31]

f. Full Implementation of 8ID DCP Concept

During OC1 the 8ID made progress toward employing a DCP concept. During OC2 further resources were to be dedicated to developing a more rugged, transportable and survivable version of the SPADS dispersed command post environment. [Ref. 8:p. 33]

g. Improved Apple Communications Gateway Station

Selecting a more powerful CGS (Requirement d.) was a long-term solution to the gateway problem. A short-term fix was required to support the 8ID DCP concept and to provide a smaller, more capable CGS for all modules. [Ref. 8:p. 33]

2. Tasks from the Statement of Work

a. Task 7: Support for REFORGER and Able Archer

This task provided for "on-site" contractor support at V Corps for 120 days. It would support a limited SPADS demonstration during REFORGER 82 and fund a test of the full-up DCP concept during Able Archer 82. It was to provide assistance to V Corps to develop SOPs for each functional area of the staff. Finally, it would provide for corrections and refinements to the software developed under Task 3 in OC1.

b. Task 8: 8ID AirLand Battle CP Program

Sub-task 8e would continue 8ID support through REFORGER 82.

c. Task 9: Baseline Support

This task provided for support during REFORGER 82, Able Archer 82, Wintex 83, and Caravan Guard IV. This support was to increase the overall effectiveness of the system, increase user friendliness and improve clarity.

d. Task 10: On-site Support through Wintex 83

This task required that the developer coordinate with the V Corps staff to clarify staff requirements for SPADS development.

e. Task 11: 16-bit Microprocessor Communications Gateway Station

Task 11 began the gateway software conversion from the Apple II 8-bit code to the Corvus Concept 16- and 32-bit code.

f. Task 12: SPADS System Training Documentation

Task 12 required that written and audiovisual instructional materials be developed. The written materials would include: (1) a User's Guide to the software capabilities, (2) a Technical User's Guide to assist system managers in operating the gateways and gaining a deeper understanding of module operations, and (3) a Concept of Operations Manual aimed at educating staff officers about SPADS.

g. Task 13: DCP Videodisc Support

This task was not specified.

h. Task 14: Support to Exercise Caravan Guard IV

The final task for OC2 provided for support for pre-exercise training, equipment upgrades, and exercise support for Caravan Guard IV. The equipment upgrades would include the new ACTO mini-SDS for the CBC and Intel modules as well as an upgrade for the Apple CGS. The Army Training Support Center, Fort Eustis, VA, provided $770,000 in March 1982 to purchase microcomputers, videodisc players, hard disk drives and computer networking equipment to support Caravan Guard IV. This was a joint effort of V Corps, ACTO, DNA, FORSCOM and TRADOC's Combined Arms Training Development Activity.[1]

3. DNA Design Principles

The second operational capability continued to follow the original five DNA design principles specified in OC1. It also added two more. These principles would be continued throughout OC2. [Ref. 8:p. 16]

a. Automate Map Graphics

The objective of this design principle was to minimize the "culture shock" problem associated with new technology. Videodisc technology was to be used to store thousands of color photographs of standard military maps. The map images were to be overlayed with standard military symbols and displayed on a color monitor. This method would avoid the use of computer-generated maps which seemed less realistic and required extensive retraining (in the early 1980s). This technique had several secondary benefits:

---

[1] Interview between R. Laird, Lieutenant Colonel, USA, Defense Nuclear Agency Alexandria, Virginia and the author, 17-18 December 1987.

1. Everyone would use the same maps

2. Various combinations of friendly and enemy units could be displayed

3. The problem of working on map corners would be minimized

All these C2 functions were carried out manually at the start of OC2. DNA believed that it would be impossible to operate efficiently in a DCP environment without automated map functions. [Ref. 8:pp. 19-20]

b. Develop a User-friendly System

Using familiar formats and simply operated equipment would ensure effective operation under high levels of stress. This design principle involved the application of the following concepts:

1. Programs would provide prompts to the operator on which steps to take to perform each function

2. The automated map display would use images of standard army maps (stored on videodiscs) that presented an identical appearance to other maps in the command post

3. The graphics backgrounds and message formats would be designed to look like the paper copies of messages already in use

Users would not have to learn any new formats, and standard Army formats would be used as extensively as possible. [Ref. 8:p. 21]

4. Exercise Objectives during OC1

The overall objective of Exercise REFORGER 82 was to conduct a limited test of the SPADS system that emphasized testing communications and components. The sub-objectives were to [Ref. 14:p. 1]:

1. Establish successful data transfer between V Corps and two 8ID elements

2. Experiment with the use of three different types of modems to determine which could best support SPADS

3. Test the uninterruptable power supply (UPS) using field generator power at 8ID and German commercial power at V Corps main CP

4. Conduct on-site training of V Corps and 8ID personnel

5. Demonstrate the videodisc system of SPADS

The overall objective of the next exercise, Able Archer 82, was to conduct a limited test of the SPADS system that emphasized two aspects: the testing of power, and the feasibility of a distributed data base system. The sub-objectives for the exercise were [Ref. 15:p. 1]:

1. Test the isolation transformers and the UPS in a field environment
2. Continue training V Corps personnel on SPADS
3. Demonstrate videodisc and plotter capabilities

The major objective during Wintex 83 was to test the capability of the SPADS prototype to provide information exchange and display capabilities in support of the DCP concept. The sub-objectives included field-testing of the recently deployed videodisc equipment and the new database management system (DBMS). [Ref. 16:p. 1-1]

V Corps deliberately limited the SPADS test objectives during Exercise Caravan Guard IV in order to concentrate on the following sub-objectives that were deemed critical to the success of the V Corps DCP experiment [Ref. 17:p. II-1]:

1. Establish and maintain a SPADS link with 8ID
2. Successfully transmit time-sensitive tactical information within V Corps and between V Corps and 8ID using EMS
3. Integrate the new ACTO mini-SDSs into CBC operations
4. Experiment with methods of updating the SPADS data base

The 8ID also limited the objectives for this exercise to:

1. Demonstrate SPADS reliability by keeping all modules operational throughout the exercise
2. Successfully transmit EMS messages among 8ID modules and with V Corps
3. Maintain the current battle data through Current Situation

Table 10 presents an overview of the exercises and objectives for OC2 [Ref. 8:pp. 28 - 30].

B. BOUNDING THE C2 SYSTEM

This section uses the same approach as Chapter III. First, the workstation bounds of the hardware and software are described. Then, the module level describes the SPADS entities and structure within the confines of one modular command post. Finally, the network level defines the SPADS system within the procedural, geographical, and hierarchical bounds that interconnect the modules.

TABLE 10
OVERVIEW OF OPERATIONAL CAPABILITY 2

	Primary Objective(s)	Date
Exercise REFORGER 82	• Interface V Corps-8ID •Improve communications gateway	Sept. 1982
Exercise Able Archer 82	•Field power system enhancements •Validate distributed data base •Deploy 8ID in vans	Nov. 1982
Exercise WINTEX 83	•Disperse full corps command post •Field Automated replicated data base •Field video battlefield display system	March 1983
Exercise Caravan Guard IV	•Disperse and displace 8ID •Create V Corps-8ID command data base	May 1983

1. Workstation Level Bounding

a. Hardware

The only new hardware introduced at the workstation level during OC2 either involved enhancements to the SDS or supported a completely new function. The five peripheral devices added to the staff duty station were a local printer, a videodisc player, a

graphics overlay device, a joystick, and a graphics tablet. The local printer reduced the competition at the SOS. The videodisc player and graphics overlay device (both required by VBDS) were packaged in a rugged case that could be placed underneath the standard SDS to support the new automated map and overlay functions. The joystick allowed the SPADS operator to scroll and zoom the picture display, offering greater control the view of the battlefield within VBDS. The graphics tablet was useful both in preparing slides and in sketching plans or evaluations of the battlefield situation to be overlayed on the map display. [Ref. 17:pp. 36-40]

The videodisc system was first demonstrated to V Corps and 8ID during Exercise REFORGER 82. Both headquarters considered it an important capability and expressed their desire to have it integrated into their SPADS modules [Ref. 13:p. 9]. The videodisc system was demonstrated a second time for acceptance testing during Exercise Able Archer 82. Again, V Corps and 8 ID were impressed by the C2 enhancements offered by these capabilities [Ref. 15:p. 8].

During the 8ID CPX in December 1982, there were a large number of hardware failures at the module, workstation and lower levels. A variety of the components needed to be repaired during this exercise (e.g., floppy disk drives, Apple microcomputers,circuit cards), and a large number of individual integrated circuit chips had to be replaced. They were destroyed by power surges, grounding problems, and unbalanced electrical loads on the SPADS equipment [Ref. 18:pp. 8-14].

An obvious factor that contributed to an incomplete test of the DCP during OC2 concerned the capabilities of the 8-bit Apple II gateway configurations. There were many valid and invalid perceptions arising from use of these 8-bit gateways. The inherent limitations of the microprocessor, as well as the manner in which software had to be written for that system, required excessive "chaining" and "swapping" to access the many

SPADS programs and to pass files through the communications gateways. These two limitations made the system very slow, particularly when under heavy use. [Ref. 16:p. II-10]

During Exercise Caravan Guard IV the long-awaited ACTO SDS was delivered. This configuration would soon be known as the mini-SDS. It became very popular with many SPADS operators and action officers, but it was particularly helpful in the cramped CPs at the division level. The ACTO SDS consisted only of an Apple II+ microcomputer, two 5-1/4-inch floppy diskette drives, a thermal printer and a single B&G monitor in a small ruggedized container. [Ref. 17:p. II-5]

b. Software

Software development during OC2 was divided between adding new functions for the SPADS user, or correcting or enhancing functions from OC1. The new functions were the Database Management System (DBMS) and the Video Battlefield Display System (VBDS). DBMS allowed the staff officer or user to maintain and manipulate data [Ref. 8:pp. 56, 60]. VBDS displayed an image of a standard military map with an overlay of both friendly and enemy unit locations, status, and other battlefield data [Ref. 8:p. 49]. One other function that was introduced was HPITS, which allowed direct access communications between two staff duty stations in different modules [Ref. 14:p. 6].

The two functions implemented during OC1, Current Situation and Electronic Mail System (EMS), were both substantially improved during OC2. Current Situation was able to access the local printer added to the SDSs, and the software was speeded up over several exercises [Ref. 17:p. II-5]. Briefing, which provided the ability to create and present briefings to the Current Situation software, was also improved during this cycle [Ref. 17:p. II-6]. The EMS code, improved during almost every exercise, allowed the operator to send or receive standard text messages, data, graphics and

computer code [Ref. 15:pp. 8-9]. Table 11 provides an overview of the OC2 software at the workstation level.

V Corps had repeatedly expressed criticism for the commercial data base products delivered as stopgaps during OC1. Some of the G1/G4 functions could be handled by commercial spreadsheet products in Local Program Execution, but their usage was limited to worksheet-type formats and processing [Ref. 14:p. 9]. The new SPADS DBMS, using the commercial data base programming language PDBase, was fielded during Exercise Wintex 83. The DBMS incorporated both BIRS and OB formats for controlled input by the G3 Operations and G2 Intelligence respectively. Tables 12 and 13 display the BIRS and OB input fields respectively. All other users could only read and get reports from the data; they did not have the capability to make changes to the data base. Table 14 shows the BIRS and OB report formats available to all users during OC2. The new VBDS function automatically extracted the current force data for overlay displays [Ref. 16:p. III-5].

The VBDS software displayed unit and battlefield data as a graphics overlay over a map image stored on a videodisc. VBDS took the data for graphics from VBDS files on the module's hard disk. These files contained information on unit location and status, control measures, and other battlefield characteristics required for a realistic automated map display. VBDS files were updated locally through the SDS with data received through the gateway from other modules. The graphics overlay was keyed to UTM[2] coordinates, and graphics were adjusted to reflect changes in scale or location. A graphics tablet was introduced for VBDS during OC2 to input additional overlay data such as phase lines or boundaries. [Ref. 8:p. 51]

---

[2] Universal Transverse Mercator projection.

By Exercise Wintex 83, the VBDS code had been rewritten to use a new videodisc platter that contained expanded map coverage and photos. The new software added a PHOTO option on the menu; this option identified all locations for which photos were available on the map being viewed. Although the G3 did not have a need for this function, several other staff sections immediately requested information on the availability of photo images and their applications. [Ref. 16:pp. III-7, III-8]

2. Module Level Bounding

The only change at the module level during OC2 was the introduction of a down-sized communications gateway station (CGS) for use in divisional command posts. This smaller model had a more limited capacity to support communications links, but was

TABLE 11
BOUNDING OC2 SOFTWARE
AT THE WORKSTATION LEVEL

Relational Data Base	**Briefing System**
• PDBase (modified)[1]	• User-defined
• Enemy and friendly force structure	
Video Battlefield Display	**Graphic Editor**
• Laser disks hold map images	• Two commercial packages
• Overlay text symbols	• Rubber band drawing
• Accesses the two data bases	• Supports graphic tablet/joystick
Electronic Mail	**System Tools**
• Commercial package	• Word processing
• Templates or free text	• Execute user software locally
• Standard communication procedures	• Network manager

[3] PDBase is a registered trademark of IOTC, Inc.

TABLE 12
BATTLEFIELD INFORMATION REPORTING SYSTEM
(BIRS) INPUT FIELDS

1:Unit ________

2:Bde ____ 3:Div ____ 4:Type ____

5:Ech ____ 6:DDHHMM ______Z____ 7:Opcon ________

8:Enemy-Action ____

9:Mission ____

OPERATIONS STATUS 10:Mech ____ 11:Arm ____ 12:Cav ____

CofMass/FLOT 13: ________

14: ________ 15: ________ 16: ________

17: ________ 18: ________ 19: ________

BATTLE RESOURCES Color Rating

20: Tank/auth ____ 21:Tank/OH ____ 22:Tank ____

23: HAW/auth ____ 24:HAW/OH ____ 25:HAW ____

26: MAW/auth ____ 2 7:MAW/OH ____ 28:MAW ____

29:Personnel ____

30:Tank ammo ____

31:HAW ammo ____

32:MAW ammo ____

33:Diesel fuel ____

34:Commo ____

35:Main-CP __________

36:TAC-CP __________

37:CDR's Overall ____

TABLE 13

ORDER OF BATTLE (OB) INPUT FIELDS

1:Report-number _____

2:Unit-ID _________ 3:Army ________ 4:Div ________ 5:Rgt ______

6:Type ____ 7:Size ____ 8:Location ________

9:Main-CP ________ 10:Forward-CP ________ 11:CE % ____

12:Activity ____

13:Cont'd ____

14:Month ___ 15:DDHHMM ______

supported by more efficient code which allowed it to operate 25 percent faster than the original CGS. [Ref. 8:pp. 31-33]

3. Network Level Bounding

The only advancements at the network level during OC2 involved implementation of the system at wider or deeper levels. The Wintex 83 Exercise was extremely successful in demonstrating that the corps headquarters could operate effectively in the dispersed mode [Ref. 16:p. II-5]. No apparent degradation of C2 functions were experienced as a result of dispersing the CP modules over a large area during that exercise; however, the true potential of SPADS capabilities was not tested due to insufficient integration of support requirements in central C2 functions [Ref. 16:p. II-6].

The following exercise, Caravan Guard IV, simulated the dispersion requirement and merely used SPADS to pass all data from one module to another. Three corps modules (CBC, FSE and Plans) were co-located in a civilian gymnasium complex while the Intel module was located nearby in command post vans. In contrast, 8ID spread its command

posts over a wide area, operating out of vans and tracked vehicles across the German countryside. The division main CP was approximately 40 kilometers from the corps main CP; DTAC was about 30 kilometers forward of the division main; meanwhile the division rear CP was located some 20 kilometers to the rear of the 8ID main CP. [Ref. 17:pp. I-2, I-4]

TABLE 14
DATA BASE REPORTS AVAILABLE DURING OC2

		BIRS REPORTS
1.	Unit Composition	Provides the composition of each unit sorted by OPCON
2.	Equipment Status	Provides the color codes for current status of equipment
3.	Detailed Equipment	Prints detailed equipment status to SOS only
4.	FLOT and TASKORG	Prints the Front Line of Troops report and Task Organization information to the SOS only
5.	Locations	Provides the UTM coordinates of friendly locations
6.	Missions	Provides the friendly unit missions sorted by OPCON
7.	Activity of Enemy	Provides a description of enemy activity in friendly sector
8.	Print All Reports	Prints a copy of each report to the local printer only
		OB REPORTS
1.	Unit Location History	Provides a history of a particular unit over time. (Requester must know the unit's name in advance)
2.	Listing of Reports by Time	Provides a listing of Intelligence reports sorted by date
3.	Combat Activity	Provides the combat activities of all units or a particular unit. Report is sent to the SOS only

C. C2 SYSTEM ARCHITECTURE

1. Workstation Level Integration

Throughout OC2, software and hardware changes produced new opportunities for the staff sections to interact with SPADS. Although only two new software packages were introduced, they generated more interest from the operationally oriented staff elements than any of the previous developments.

The next two figures present the integration of the two new software functions with the C2 system and the C2 process. Figure 4.2 displays the integration of system, process and function with the Database Management System [Ref. 8:pp. 58-60]. Figure 4.3 shows the integration of entities, structure and functions with the Video Battlefield Display System software [Ref. 8:pp. 53-55].

2. Module Level Integration

The addition of SPADS hardware and software slowly influenced the structure, organization, procedures and information flow patterns of the V Corps and 8ID command posts. In OC2 it gradually became clear that without expressed command interest in this experiment, only certain staff sections or elements would voluntarily take up SPADS as an effective C2 toolset; most staff sections just ignored SPADS during the exercises. The G3—the proponent of operations, plans and training—would have been the logical driving force behind a system that could restore effectiveness to the dispersed CP configuration. That was not the case, however. Only two modules—Fire Support and Plans—took full advantage of SPADS.

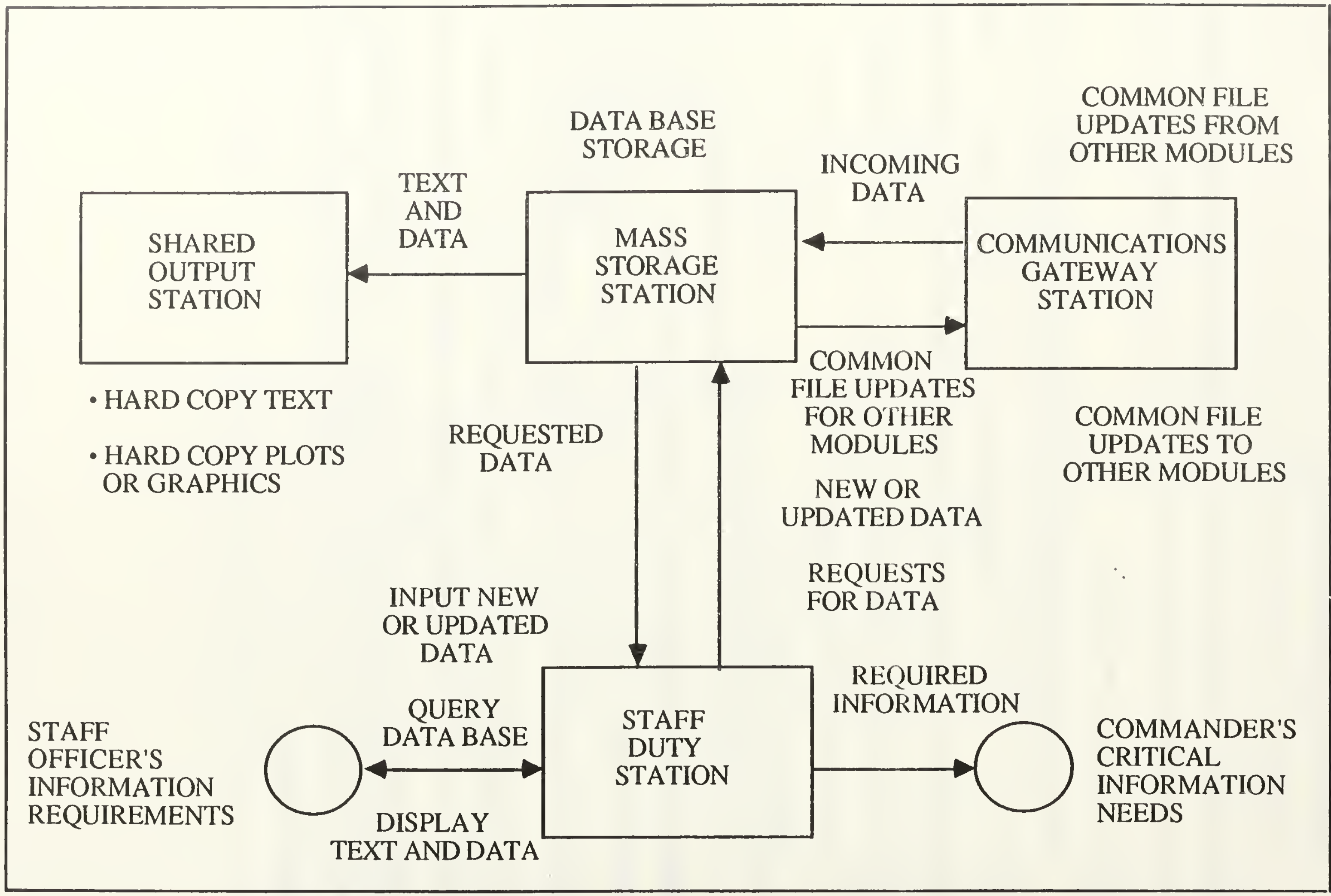

Figure 4.2. Integration of Data Base Management System

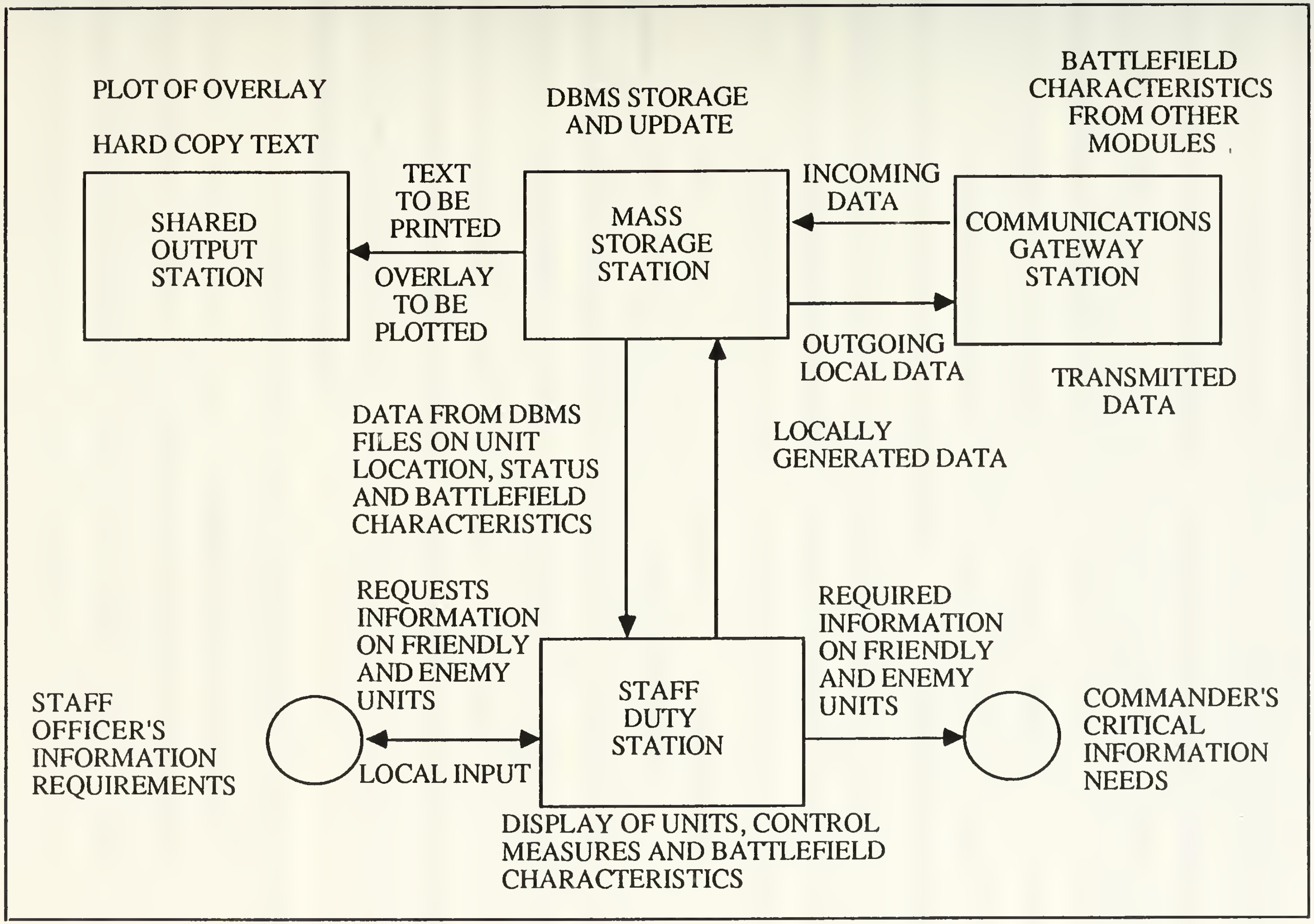

Figure 4.3. Integration of Video Battlefield Display System

a. Fire Support

The V Corps Artillery leadership, from the commander and the Assistant FSCOORD down to the FSE staff and NCOs, demanded that SPADS meet their needs for targeting and fire support management. Those leaders invested in SPADS by making valuable personnel available for training and then assigning them to primary SPADS duties during all exercises. The FSE module achieved SPADS self-sufficiency before any other modules. The FSE staff developed its own procedures for integrating SPADS operations into primary functions before any exercises and tested them throughout OC2. At FSE's initiative, FSE and Intel modules established their own network and procedures for using SPADS to improve the processing and passing of critical targeting data for the deep attack [Ref. 16:pp. II-15 -II-16]. The TCATA evaluation during Exercise Wintex 83 found that the FSE's procedures worked extremely well [Ref. 16:pp. II-22 - II-25].

b. Plans

The G3 Plans and Exercise officer selected a highly talented and aggressive NCO at the beginning of OC1, sent him to all of SPADS training, and assigned him as the module system manager. The G3 Plans came to expect the system to speed up and smooth all of the internal operations of the module. All Plans action officers soon became adept at using the system to produce and transmit OPLANS during exercises. In Exercise Wintex 83, the Plans module transmitted ten OPLANS and seven changes; this represented a 400 percent increase over previous exercise results. The Plans module had the highest system usage per individual during Exercise Wintex 83. [Ref. 16:p. II-17]

3. Network Level Architecture

There are two perspectives in examining the network level architecture during OC2: connectivity and procedures. Communications were finally starting to support SPADS by the end of OC2. In addition, numerous novel connections were made to the

gateways during this cycle. On the other hand, integrating the expanding network architecture into the organization and procedures of the corps or division had been a complete failure. This section examines these two aspects of the network level. Once the corps was able to support the DCP concept through SPADS communication gateway stations, it was in a position to begin integrating the V Corps C2 process from individual staff duty stations throughout the entire network.

a. SPADS Connectivity

Individuals continued to achieve resourceful solutions to communications problems throughout OC2. During REFORGER 82, soldiers from the 8ID decided to connect the 8ID TAC CP gateway to another gateway some 180 feet away using WD-1 field wire. This experiment worked so well that they used that connection for the remainder of the exercise. [Ref. 14:p. 8]

The V Corps Commander requested that the V Corps main CP SPADS gateway connect to a VII Corps pre-production model AN/UYQ-30, Tactical Computer Terminal (TCT). One staff duty station was hardwired to the TCT using a military version of an RS-232 interface. Not only were the two systems physically linkable, but they could transfer files between them. DNA observed this pairing as a possible candidate for future interoperability funding. A successful project along these lines would have given the V Corps automated C2 system a means to communicate with the VII Corps militarized, automated C2 system. [Ref. 14:p. 9]

By exercise Caravan Guard IV, V Corps had learned how to effectively use the corps multichannel system to support the SPADS network. The Corps C-E section had begun to understand how to accommodate SPADS requirements, and the After Action Report indicated that the corps could make further progress in the future. [Ref. 17:p. II-13]

b. Procedures

At the start of OC2 there were no SOPs—at any echelon—for the employment of SPADS. By Able Archer 82, V Corps had begun to make limited progress towards identifying the information necessary to develop a SPADS SOP. There was no 8ID document related to the preparation or deployment of SPADS [Ref. 15:pp. 7, 10]. A new set of SPADS manuals were delivered to V Corps in January 1983. The Operator and System Manager Manuals were distributed immediately, and SPADS operators took these manuals to the field during the last two exercises. The Staff Officers' Manual, however, was not even read by those officers with primary SPADS responsibilities. Even though guidelines for an extensive SPADS SOP were contained in the manual, no SOPs were developed by any staff section after this information was distributed. By Caravan Guard IV only a Current Situation SOP had been developed by any staff section within V Corps. [Ref. 17:p. III-12]

Two of the primary lessons V Corps learned after the series of exercises that culminated in Wintex 83 were that: (1) evolutionary development must be based upon user identification of needs, and (2) system capabilities must be designed and/or enhanced in accordance with deliberate plans to integrate SPADS into the V Corps C2 processes. Unfortunately, throughout OC1 and 2 there had been no systematic approach to defining and testing user applications or in integrating them into command post routines [Ref. 16:pp. II-26, II-27]. The TCATA evaluation of SPADS during Wintex 83 should have forced the commander and the staff to recognize their situation. The outbrief was honest and to the point: V Corps either had to embrace SPADS and internalize it within the corps C2 system, or it had to abandon it entirely. [Ref. 16:pp. II-27, II-28]

c. Inhibiting Factors

The two principal factors inhibiting the progress of SPADS throughout the first two OCs were: (1) insufficient primary staff emphasis, and (2) insufficient integration of SPADS into the V Corps C2 processes [Ref. 16:pp. II-8 - II-10].

V Corps had not placed sufficient emphasis on educating primary staff officers on the value a distributed data base had in meeting their needs. The DCP concept represented a dramatic change in traditional C2 procedures. These applications were seen as foreign to tactical operations by many senior officers [Ref. 12:pp. 21-22]. Many senior officers conceded that these methods might have value; some even gave them verbal support. But almost uniformly throughout the V Corps CP, their subordinates were isolated from the staff duty stations and SPADS products during exercises [Ref. 16:p. II-8].

Conceptually, the SPADS distributed and replicated data base could have provided the V Corps commander with the critical common perception of the battle and with specific information required for timely decision making. Unfortunately, most of the primary staff had not devoted any time to learning SPADS, nor had they directed their overburdened subordinates to use or learn SPADS. As a result, most staff sections could not identify information flows that would satisfy their own C2 functions by the end of OC2. [Ref. 16:pp. II-8 - II-9]

d. Contributing Factors

Exercise Caravan Guard IV demonstrated to V Corps and 8ID commanders that SPADS could have been a reliable tactical C2 system during the DCP experiment if they had devoted resources to proper planning and operational procedures. They considered the overwhelming success of these exercises as the first step in a new phase of SPADS development. At the post exercise In-Progress Review, V Corps adopted a draft

SPADS charter (displayed in Table 15) and adopted a tentative plan for a new organizational element for controlling SPADS within V Corps. [Ref. 17:pp. II-14 - II-16]

TABLE 15
V CORPS SPADS CHARTER

- Develop a DCP program plan with specific exercise objectives
- Identify and prioritize information needs to support procedures and decision making
- Define how SPADS works in each module
- Develop a SPADS program plan with specific exercise objectives, training requirements and organizational responsibilities
- Develop SOPs for DCP and SPADS
- Conduct mini-CPXs in garrison prior to each exercise

D. DATA GENERATION

The data generated for this OC are shown in Table 16.[3] The data generation worksheet and formulas discussed in Chapter II were used to produce values for this OC. The means for each evaluation category are displayed in Figure 4.4. The next paragraph briefly discusses the data generation procedures presented in Chapter II.

---

[4] The following sources provided raw data on OC2 exercises: Ref. 13 (REFORGER 82), Ref. 14 (Able Archer 82), Ref. 15 (Wintex 83), Ref. 16 (Caravan Guard IV), Ref. 17 (8ID CPX).

TABLE 16
DATA GENERATED FOR EACH EXERCISE DURING OC2

Measurement Categories	REFORGER 82	Able Archer 82	8ID CPX	Wintex 83	Caravan Guard IV
FAIR	18	12	7	34	32
Timeliness	4	2	4	7	7
Capacity	4	2	4	7	7
XMOTi	**26**	**16**	**15**	**48**	**46**
Dispersion	1	2	2	5	6
Redundancy	0	0	0	3	0
Continuity of Operations	5	2	5	14	14
XCSTi	**6**	**4**	**7**	**22**	**20**
C2/FE	**32**	**20**	**22**	**70**	**66**

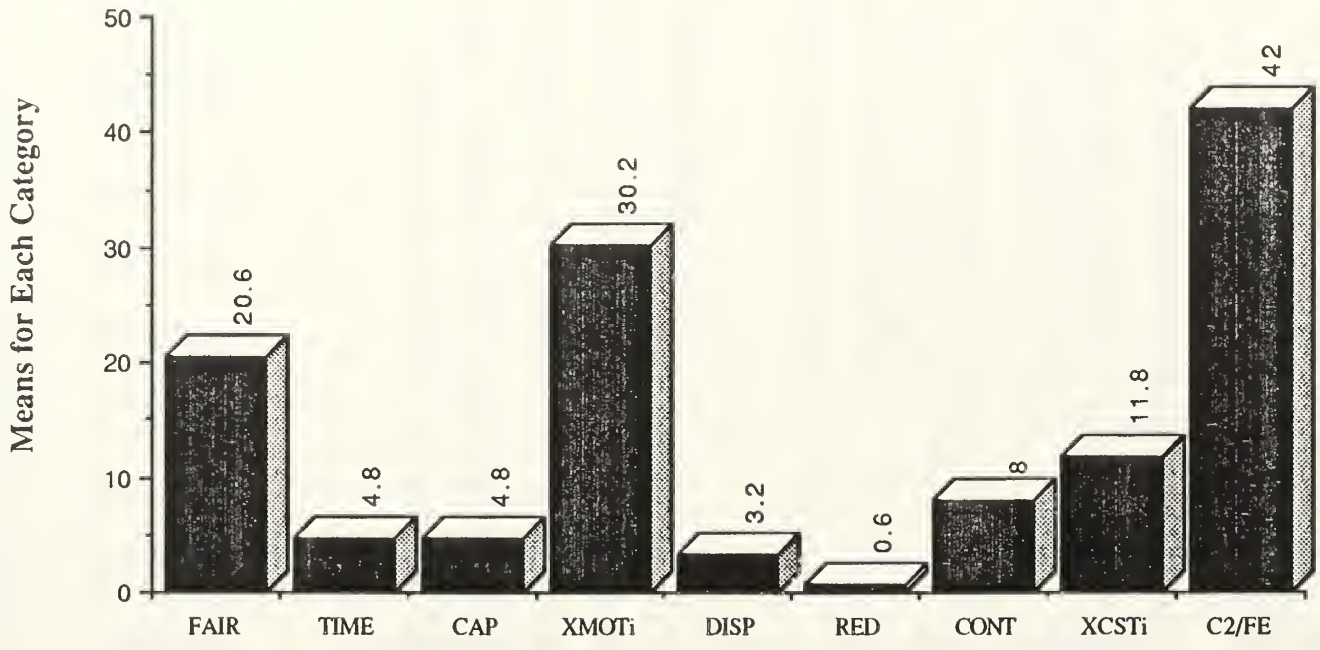

Figure 4.4. Means for Each Category During OC2

To begin the data generation for this operational capability, after action and lessons learned reports were collected for each exercise from V Corps, DNA, and the developer. Using the worksheet, definitions, and procedures specified in Chapter II, values were determined for every measure from each exercise. The measures were individually considered as binary conditions for each DCP module that participated in the exercise being evaluated. The summed measures (e.g., FAIR, XMOTi, and XCSTi) received their cumulative, unweighted scores based upon their constituent measures of performance or effectiveness. The final measure, C2/FE, was calculated using the procedure specified in Chapter II. The results for each exercise are displayed in Table 16, and the means for each evaluation category are shown in Figure 4.4.

E. AGGREGATION AND INTERPRETATION OF MEASURES

The extensive information available in these After Action and Lessons Learned Reports (Ref. 14 - 18) contained a great deal of data and were extremely helpful in understanding the characteristics of the experiments during the exercises.

1. C2 Mission Orientation

The value of C2 Mission Orientation, XMOTi, seems to start at approximately the same level as OC1, drops sharply and then rises dramatically at the end of OC2. There is a measurable gain in effectiveness by the end of the experiment period; however, there was a tremendous loss of functionality during the period of REFORGER 82 through the 8ID CPX in December 1982. The following three sections interpret the three components of C2 Mission Orientation.

a. C2 Process

There was a dramatic loss in functionality from the end of OC1, in June 1982, through the 8ID CPX that December 1982. While the functions of the V Corps commander and staff may have remained constant, the DCP environment and SPADS, in

particular, caused a severe decrease in the commander's and staff's abilities to exercise command and control of the corps. Only the sharp rise in FAIR values during the last two exercises represents the increasing functionality of the SPADS system within the DCP environment.

b. Physical Entities

Physical entities continued to change during OC2. Some new software was introduced, established software functions were constantly refined, and new hardware was integrated into the DCP environment. The value of capacity does not remain constant for each module that was already in the V Corps DCP. As the modules were rearranged from exercise to exercise, the system's capacity diminishes until the exercises in spring 1983. Then, the total aggregated value increases as the modules were networked by the communications gateway stations to one another through TASS.

c. Structural Components

The value of the structural measure rises slightly, decreases again, and finally steadies at the end of OC2. For the first time, SPADS was able to accomplish the transmission of *critical information required by the commander*. Despite peak transmission periods and temporary communications outages during each exercise, SPADS was finally able to provide the V Corps commander with dependable, critical, decision making information.

2. <u>Command Survivability</u>

SPADS continued to make significant gains towards achieving command survivability during OC2. Except for the initial three command post exercises, dispersion between modules gradually increased and more modules were added to the corps system. Continuing the trend from OC1, no progress was made toward redundancy; this continued

to be specifically related to command influence and staff interest. Finally, the values of reliability and transportability remain constant for each module during OC2.

3. C2 Force Effectiveness

SPADS did evolve during the operational capability based upon the operational lessons learned. It was still not clear how much progress SPADS had made during this 19-month period. The evolution involved hardware, software, protocols and communications interfaces. SPADS only began to affect the organization, procedures or concept of operations for the V Corps command posts at the end of OC2, during the Caravan Guard IV In-Progress Review [Ref. 17:pp. II-14 - II-16]. The values of C2/FE rise distinctly at the end of the experiment period when the V Corps and 8ID scaled objectives down to realistic levels and sought to gain maximum advantage from their automated C2 system. The values of all significant measures, i.e. XMOTi, XCSTi and C2/FE, nearly double in value by the end of OC2.

Figure 4.5 provides the cumulative (unweighted) value of each evaluation category for each exercise of OC2. Figure 4.6 displays the changing value of each measure—XMOTi, XCSTi, C2/FE—throughout each exercise of the second operational capability.

F. SUMMARY

The second operational capability was a turbulent period for V Corps, 8ID and DNA. All of these organizations had specific objectives for this period, and all of their objectives failed to some degree. This section frankly discusses procedures, training, communications, hardware and software as they relate to the performance of the V Corps and 8ID DCP experiments.

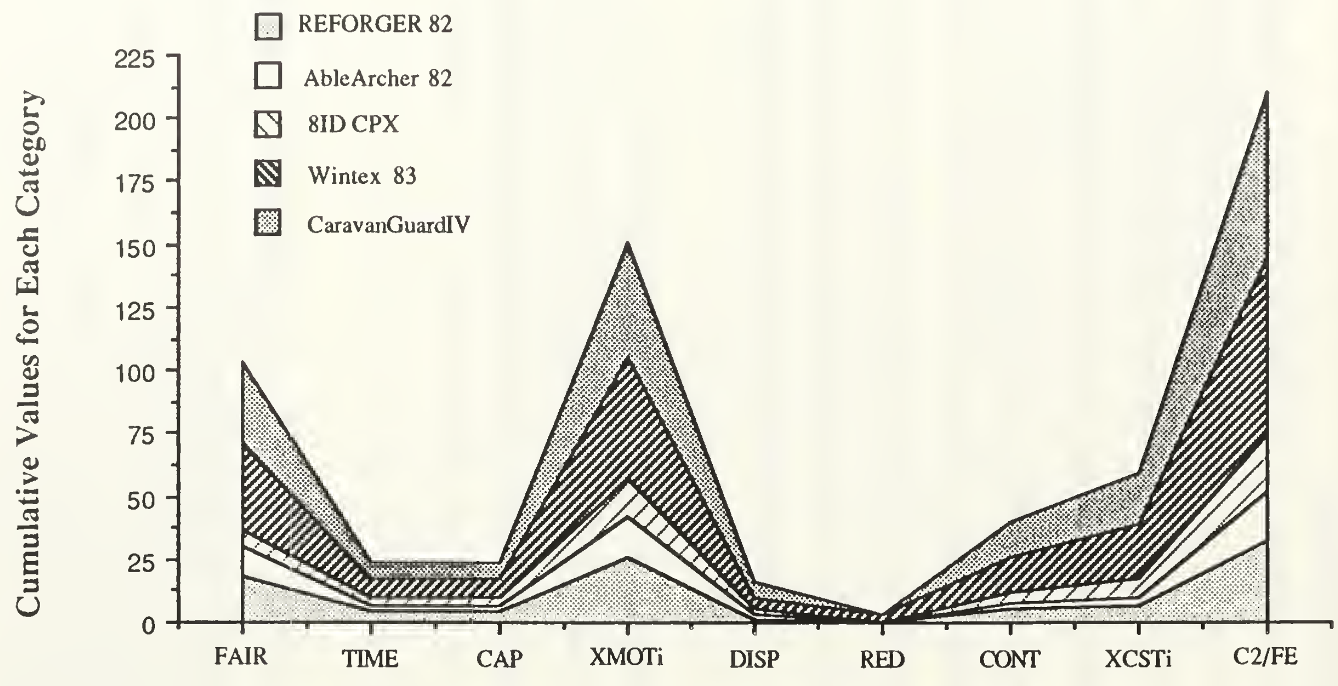

Figure 4.5. Evaluations of the Three Problems for OC2

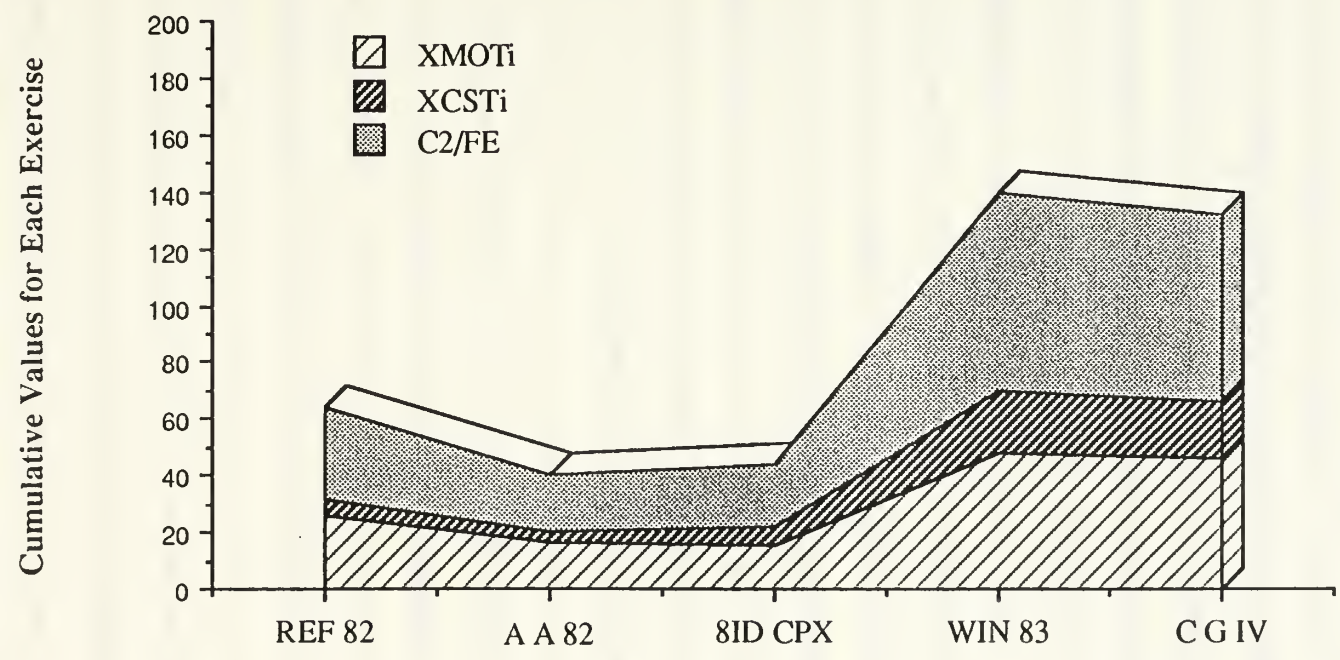

Figure 4.6. Comparisons of the Three Measures for OC2

The lessons learned from the SPADS evolutionary development cycle must focus on procedures and training because these two structural components are critical to the success, or lack thereof, of a prototype C2 system. To a large extent they determine the effectiveness of the fielding and implementation. System designers should have been more careful planners, thoughtful schedulers and more cognizant of requirements, committed to successful implementation, and engaged in a systematic training program if they wanted to insure SPADS user effectiveness. This does not imply that system and personnel problems, diagnoses, fixes and modifications that resulted as a response to system problems would not have occurred. These situations are a necessary part of any rapidly fielded system. The lessons learned by users in the field environment are the basis for system improvement and enhancement in an evolutionary development cycle. The scope and speed of the system's advancement, measured objectively, was significantly influenced by staff priorities for the system, SOP construction and revision, and the staff's attitude toward effective training and retraining. [Ref. 8:p. 65]

1. Procedures

Throughout the evolutionary development cycle, there was evidence that a highly reliable tactical command and control could only be implemented if adequate planning and operational procedures were employed. A critical factor in the success of this evolutionary development program was the careful definition of minimum essential information and the data distribution architectures by the headquarters staffs. This essential step was almost totally lacking throughout the first two operational capability cycles. [Ref. 8:p. 65]

Emphasis should have been placed upon soliciting and coordinating staff requirements of the corps and division headquarters. These staffs significantly failed to produce a working SOP that reflected the flow, storage and retrieval of messages, data ,or briefings from SPADS. Without this document, staff requirements could not be translated

into data to support the distributed C2 system. Also lacking was a listing of the operator and staff officer responsibilities for information processing procedures. The SOP should have indicated who, what, when, where and how each test of the DCP program related to the functions that were being supported by the staffs. Little time was available for this critical document, and there is no evidence that any was expended to accomplish this task. Its completion during OC2 would have greatly enhanced the quality of implementation and the rapid fielding of the distributed C2 system. [Ref. 8:p. 69]

2. Training

The headquarters' staffs should have carefully scrutinized the personnel selected for training. They did not ensure that potential operators and system managers had sufficient time to gain experience with SPADS. Experienced SPADS users could have clearly identified those procedures that could have been better automated, pinpointed obsolete functions or equipment, and identified the manner in which new operational procedures could have been implemented. The corps would have obtained an ongoing program that produced quality operators and system managers who could have significantly contributed to fine tuning SPADS to meet the Army's needs. [Ref. 8:p. 67]

Two other integral training program components were lacking. On-the-job training and pre-exercise rehearsals were equally necessary for users to understand the enemy threat, the constraints of the exercise scenarios, and the functions of SPADS in the DCP environment.

Training documentation should have reflected the level of sophistication of the commercial technology and should have been incorporated into SPADS itself. Self-paced documentation could have been available for the user who recently joined the organization or who missed the formal training cycle. On-line tutorials using SPADS videodisc technology could have been substituted for the lengthy manuals to assist the operator in

learning how to set up and operate the staff duty stations. A critical oversight was the lack of a small, weatherproof, pocket-sized reference manual that could be carried by the operator or permanently affixed to the SDS; this would have been superior to the bulky system documentation that was nearly always damaged or left behind by staff officers and users. [Ref. 8:p. 67]

Finally, data file development for future exercises should have been initiated as soon as possible within the guidelines of the requirements document and completed before the anticipated move to field locations. Selected operator refresher training could have been conducted concurrently with this development. Following the move to the field, immediately after system equipment and communications were installed and operational, testing and demonstration of the system should have begun. These tests and demonstrations should have included mini-exercise, requirements-driven scenarios to insure a comprehensive shakedown of SPADS prior to commencement of the exercise. [Ref. 8:p. 69]

3. Communications

Both the V Corps Signal Brigade's and Communications-electronics (C-E) staff section's lack of involvement with SPADS during the first two OCs severely affected its development. Their early involvement was absolutely necessary for an initial good start as well as to planned progress during the following evolutionary development cycle. As military technical consultants to the system, they possessed the ability to determine whether the system could actually meet the operational needs of the V Corps DCP concept. These communications experts would have been an excellent source of advice in the planning of exercises, and could have insured that operational staff sections conformed to the new automated procedures. [Ref. 8:pp. 74-75]

Instead, serious interoperability problems caused major time delays and adversely affected the goals and purposes of numerous exercises and tests. The C-E staff's involvement would have insured that essential time was devoted to testing the system, observing the man-machine interface, obtaining user feedback, evaluating system usability and meeting the requirements of the OC. Moreover, these communications experts could have predicted avoidable problems that seriously frustrated new operators and system managers who were often uncomfortable in their roles, and could have contributed to the success of many DCP exercises. [Ref. 8:p. 74]

Another area where expert help was needed was in the communications method used to connect local modules to one another and to other modules at longer distances. Operational users failed to learn a basic lesson: before deploying to the field, users need to devote considerable time to planning and pre-exercise engineering in order to ensure a sufficiently good system interface and a better chance of success for communicating between microcomputer based systems. The C-E staff was already planning and engineering tactical multichannel systems, and they should have assimilated SPADS into their area of responsibility. [Ref. 8:p. 74]

Regardless of the technological advances or the sophistication of the system enhancements, SPADS could not meet its stated objectives unless the communications problems—especially with the interface—were remedied. Experienced communications planners were needed to make provisions for the distribution of information among echelons vertically as well as horizontally across staff support functions. The V Corps Signal community's lack of involvement prevented reliable and reasonable communications capabilities from being planned for and employed during the first two operational capability cycles. The most significant problem in communications was not with the communicators

(who ignored SPADS), but with the lack of command influence which should have insured that professional communicators were involved in SPADS from the outset. [Ref. 8:p. 75]

4. Hardware

The hardware lessons learned during OC2 interact with the lessons learned in preceding summaries. The relatively minor hardware problems which developed during the first two OCs indicated that the evolutionary development cycle is a good means to fine tune hardware components that have to be fielded quickly. The successes of the SPADS system hardware in meeting and exceeding user requirements resulted from an early fielding strategy and hands-on use that supported the effectiveness of the evolutionary development concept. [Ref. 8:p. 83]

It may seem obvious that hardware had to be integrated with software into a usable system that automated the V Corps operational procedures to benefit the DCP. However, the field users, DNA, and the developer had to develop a three-way dialogue before they could produce and field a C2 system that permitted the staff to operate more efficiently and allowed the commander to control his forces effectively. The hardware had to possess the capabilities required to support the system software. Moreover, the software had to be tailored to meet limitations of the hardware that were first identified during field tests and exercises. Only in this manner could the users distinguish between hardware and software problems in the SPADS system. [Ref. 8:p. 82]

Hardware that was difficult for the average military user to operate and maintain would be abandoned as inoperable during high stress periods—when it was most needed to contribute to a survivable system. The proponent of the system and the developer should have actively obtained feedback about the system hardware. Staff officers, who depended upon SPADS information processing and decision support capabilities, could have been among the best reviewers of hardware failures and inadequacies. Moreover, senior staff

officers were in a unique position to judge how the staff adjusted operational procedures to the constraints imposed by the system hardware. Likewise, the advice of SPADS operators would have been valuable because they were closest to the hardware problems and were the most likely to make worthwhile judgments regarding its usability. [Ref. 8:pp. 82-83]

5. Software

The interaction effects among the other system components (procedures, training, communications, hardware and user inexperience) adversely affected the capability of SPADS software to adequately perform its intended functions. Software development should have taken these constraints of the users' environment into consideration. A positive example of such an adaptation was how the developer, after gaining an understanding of military communications traffic loads on TASS, developed software that only transmitted the data that were absolutely essential. It was not necessary to transmit entire files. Other successful examples include message formats being stored on every module's hard disk and all maps being stored on videodisc. Once again, only the new data required to fill in reports or to show unit locations on map overlays had to be transmitted and received. [Ref. 8:pp. 87-88]

During the first OC, there were many instances where usability, storage, update or retrieval interfered with SPADS effectiveness. Throughout the second OC the developer made a concerted effort to minimize those software deficiencies that adversely affected operations. However, the initial fielding and testing of software was absolutely essential in order to identify those shortcomings that could be diagnosed and corrected before the following exercises and test. [Ref. 8:p. 86]

The majority of the software problems that occurred during the second operational capability related to the following tasks [Ref. 8:p. 85]:

1. Tailoring software to meet operational user requirements or automation needs
2. Increasing software speed and efficiency
3. Fine tuning system software to make it more usable and responsive to staff officers' needs
4. Eliminating system software bugs that impede the execution of system utilities
5. Advancing the software's technological capabilities to perform more sophisticated staff operations
6. Integrating existing and new software with hardware enhancements that develop as the system matures or the staff functions change

Although much of the responsibility for software remained with the developer, staff officers should have ascertained which operational functions and procedures required automation early in OC1. These officers should have developed SOP documentation that clearly addressed those considerations so that hardware meeting those software requirements could have been carefully selected and developed. And they should have identified appropriate data structures to support the software development. The developer could not foresee future changes of the system, so staff officers should have concisely specified the procedures and functions that would benefit most from software development. [Ref. 8:p. 87]

6. Outlook

This chapter's summary catalogued the myriad sources of problems that afflicted the SPADS experiment throughout OC2. In spite of these observations, it was clear that DNA saw SPADS as continuing to make significant progress towards the fully dispersed command post concept for both the corps and the division. Capabilities demonstrated in the exercises during 1982 and 1983 verified the viability of the DCP concept in employing a prototypical dispersed C2 system linked through standard tactical communications. By the end of OC2, many necessary improvements to fully implement the DCP concept and fully support SPADS had been identified. Therefore, DNA decided to continue the

experiment through the end of Fiscal Year 1985 to fully demonstrate the concept and to identify and improve the methodology by which it could be fully implemented.

V. OPERATIONAL CAPABILITY 3

A. PROBLEM DEFINITION

Funding for the third operational capability started in July 1983 and field-testing began in September during REFORGER 83. OC3 was planned and designed to start with the first two operational capabilities as a baseline condition and progress from there. Once again, designs and capabilities were tested and refined during the OC's five exercises: REFORGER 83, Able Archer 83, Crested Eagle 84, Caravan Guard V, and REFORGER 84. The Army conducted an external evaluation of SPADS during Wintex 85; this one exercise is also considered part of the evaluation.

This section addresses four issues central to problem formulation:

1. What were the stated requirements of OC3?
2. What tasks from the statement of work (SOW) supported OC3?
3. What other design principles, mandated by DNA, guided the development?
4. What were the goals of each exercise?

Figure 5.1 shows the eight requirements of OC3 along a month by month timeline. The dates of the five exercises during OC3 are marked by "•," below the central rectangle. The objectives of OC3, based upon requirements and technological characteristics, are shown to the right.

1. Requirements for OC3

The eight OC3 objectives to be completed during the final 20-month period of the DCP experiment were to: (1) develop a mini-staff duty station for G3 ACTOs and divisional use, (2) modify equipment for use in vehicles, (3) develop interface requirements for other C2 systems, (4) develop interactive graphics, (5) refine/enhance the database

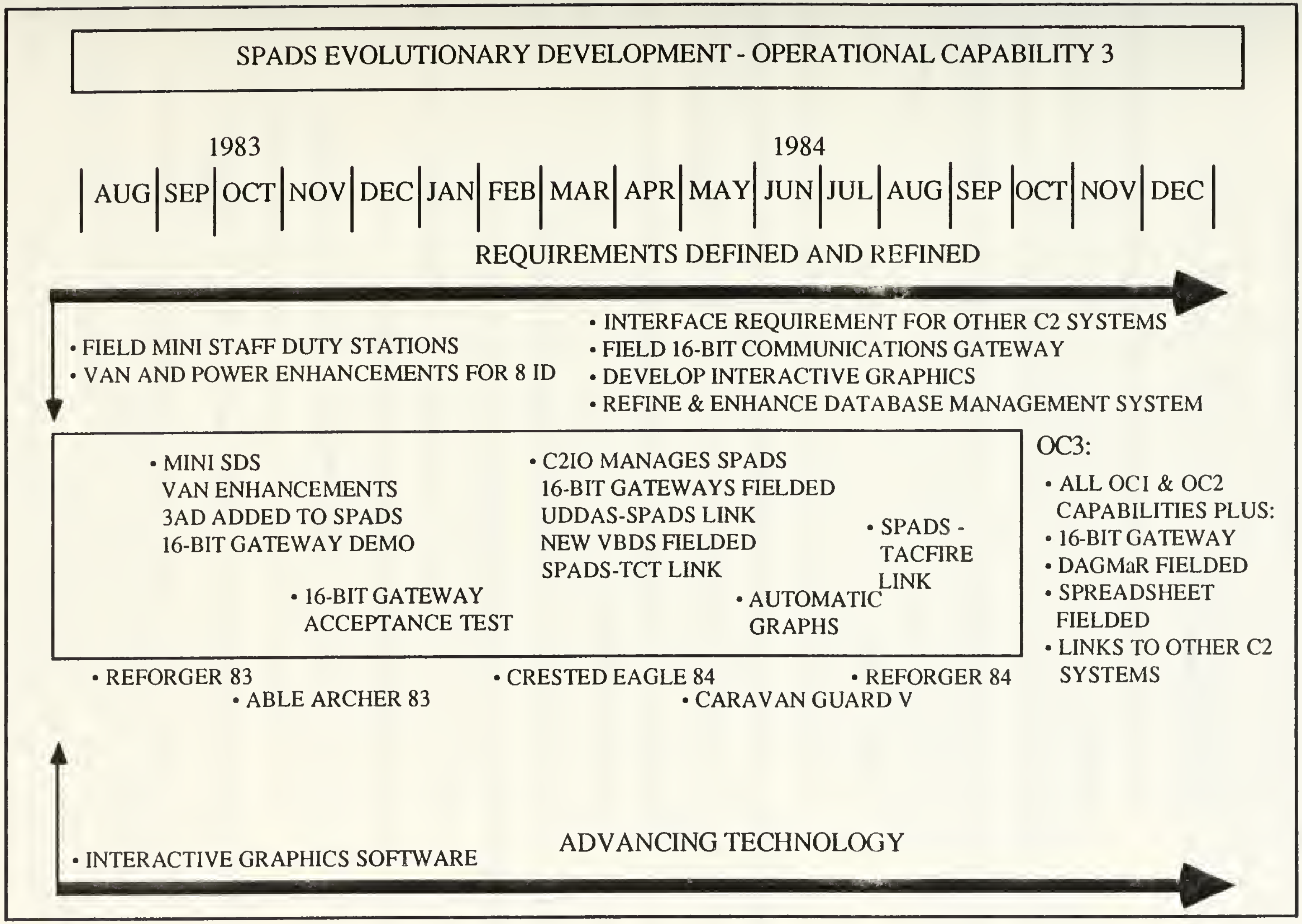

Figure 5.1. Overview of Operational Capability 3

management system, (6) field a 16-bit communications gateway station, (7) prepare V Corps for self-sufficiency, and (8) complete the V Corps DCP concept.

a. Develop a Mini-Staff Duty Station for G3 ACTOs and Divisional Use

Four ACTO SDSs were demonstrated for acceptance testing during OC2. Based on overwhelming staff action officer acceptance, DNA decided that all non-VBDS staff duty stations for the 8ID should be converted to the mini-SDS. In addition, once the new 16-bit gateways were fielded, the older Apple gateways would be converted into mini-SDSs for distribution to other units. [Ref. 17:p. II-5]

b. Modify Equipment for Use in Vehicles

The 8ID experienced recurring hardware, grounding, and power problems throughout OC2. During Exercise REFORGER 82, 8ID tested UPSs with field generators and German commercial power to determine whether these devices could protect SPADS equipment. [Ref. 14:pp. 1-6] During the 8ID CPX in December 1982, there were a large number of failures on the local area network, within the SDSs and at the gateways. Numerous interface cards and integrated circuit chips were destroyed by power surges, grounding problems, and unbalanced electrical loads. [Ref. 18:pp. 8-14]

DNA specified that hardware solutions would be implemented to protect the 8ID SPADS equipment when it was operating in the M-4 vans.

c. Develop Interface Requirements for Other C2 Systems

The successes during past exercises produced the requirement for interconnectivity with other Army C2 systems [Ref. 14:p. 9] The requirements for OC3 were to develop rigorous interface specifications or protocols for: (1) MICROFIX, (2) the Tactical Computer Terminal (TCT), (3) TACFIRE and (4) the Target Analysis and Planning (TAP) program. [Ref. 8:pp. 33-35]

d. Develop Interactive Graphics

During past operational capability cycles there had been limited success with the timely production of manually generated decision graphics. This shortfall would be the impetus for a software effort that integrated information from SPADS DBMS and Briefing to produce an automatically updating decision graphic for Current Situation.

e. Refine or Enhance the Database Management System

V Corps G3 Operations and several other staff sections had expressed a need for data bases with additional functions. The G3 had also requested that instructions be given to key V Corps staff personnel on the construction of data bases using SPADS DBMS. [Ref. 16:p. III-6]

During Caravan Guard IV staff users suggested that more rapid data base updates could be accomplished in future exercises if the data bases were updated directly, rather than through information passed by electronic mail [Ref. 17:p. I-4].

These two user requirements would be implemented during OC3.

f. Deploy a 16-bit Communications Gateway Station

The original 8-bit gateway could not meet the needs of the V Corps DCP by the end of OC2. Task 11 of the SOW required the developer to convert the 8-bit gateway code to the 16-bit microcomputer selected for the new gateway. New CGSs were needed to increase the speed of message traffic transmission and reception, to reduce LAN and hard disk contention, and to produce more efficient management of the module's computer resources. [Ref. 8:p. 33]

g. Prepare V Corps for a Successful Transition to Self-sufficiency

DNA selected V Corps to be the testbed for the DCP experiment in 1981. The agency had provided all guidance and logistics, as well as most of the funding, through the end of OC2. One of the conclusions of the Caravan Guard In-progress Review

(IPR) was that V Corps should develop a plan to manage SPADS as an Army C2 program. The V Corps Charter, presented in Chapter IV, would be the starting point for the transition to self-sufficiency. [Ref. 17:pp. II-14 - II-16]

h. Complete the V Corps DCP Concept

The completed V Corps DCP concept would consist of: (1) horizontal command and information flow throughout the dispersed corps modules, and (2) vertical command and information flow from the corps commander to his immediate subordinate combat commanders in the 3AD, 8ID, 11ACR, and 12CAG.

2. Tasks from the Statement of Work

a. Task 15: Provide Extended Exercise Support

Test objectives and key data elements needed for the evaluation of V Corps DCP exercises were to be identified for each CPX, FTX, etc. so that systems evaluators from supporting Army agencies could monitor the progress of SPADS during OC3.

b. Task 16: Provide Continued Hardware and Software Development for the DCP Program

The developer was to accomplish two tasks: (1) refine or correct software problems identified in past exercises, and (2) continue 16-bit microprocessor CGS development.

c. Task 17: Provide Exercise Support

In July 1983 TRADOC provided $1.4 million to provide support to the V Corps and 8ID DCP programs through the second quarter of fiscal year 84 (FY 84). The Army Command and Control Initiative Program (TACIP) was to monitor the accomplishment of this task.[1]

---

[1]Interview between R. Laird, Lieutenant Colonel, USA, Defense Nuclear Agency, Alexandria, Virginia and author, 17-18 December 1987.

d. Task 18: Software Support

The developer was tasked to: (1) continue development of the 16-bit communications gateway, (2) continue user identification requirements, and (3) customize software for division usage.

e. Task 19: On-site Support for the DCP Program

This task required the developer to establish an on-site support facility at V Corps Headquarters in Frankfurt, West Germany. The facility would be completely furnished with tools, documentation, and spare parts and be supported by an integrated logistics support plan. Two full-time employees, a software developer and a systems integrater, were to provide on-site support 40 hours per week in garrison and as required during exercises. [Ref. 8:p. 20]

f. Task 20: Continued Support

The first part of this task would provide software support and corrections during exercises. It would also improve the SPADS database management system and integrate the DBMS with automatic graphics output. It would investigate the display of improved decision graphics information and require that the SPADS communication software be modified to implement both TCT and MICROFIX protocols.

g. Task 21: Field a 16-bit Communication Gateway Station

The developer was required to accomplish the following at V Corps: (1) field a 16-bit microcomputer-based CGS, (2) install the 16-bit CGS, and (3) conduct training for the new gateway.

h. Task 22: Transition Training and Support

This final task of OC3 was supposed to assist V Corps and 8ID SPADS users in preparing to be self-sufficient after FY 84. The developer was required to: (1) conduct pre-exercise support and evaluation and assist commander and staffs in identifying

SPADS objectives and performance standards based upon such objectives; (2) conduct technical support for Caravan Guard V and REFORGER 84; (3) publish post-exercise reports; (4) conduct an expanded training program at V Corps; and (5) update all documentation, revise the User's Manual, and produce a free-standing reference flip card set.

TRADOC provided $350,000 for this task in February 1984; the first $190,000 was to be used by 30 September 1984 and the final $160,000 used by 30 September 1985.[2]

3. 8ID REFORGER 84 Statement of Work

The 8ID developed a separate statement of work to support the plans that they had developed for REFORGER 84 [Ref. 20:pp. 1-2]. (These plans are discussed in detail later in this chapter.)

a. Task 1: Develop a Hardwire Interface Between a SPADS Workstation and a TACFIRE System

This task required that a MILSTD 188 interface to TACFIRE be developed. This interface had to be capable of transferring data files between the TACFIRE and SPADS systems as well as passing free text from SPADS to TACFIRE.

b. Task 2: Develop a System for Automatically Updating SPADS Position Location Data Bases Based Upon Electronic Information Provided by TACFIRE

The developer was required to develop a system to receive and interpret the data base information coming from TACFIRE through the hardwire interface. The SPADS system was required to insert this data into a PDBase relation within the DBMS.

---

[2]Ibid.

c. Task 3: Provide On-site Exercise Support to 8ID During REFORGER 84

Support was to be provided at the pre-REFORGER CPX as well as throughout REFORGER 84. The 8ID personnel were to be trained on the following SPADS II[3] capabilities: briefing, graphics systems, and the DAViD videodisc system.

4. DNA Design Principles

The third operational capability continued to follow the seven DNA design principles specified in OC1 and OC2 [Ref. 8:p. 16].

5. Exercise Objectives during OC3

V Corps would use SPADS during Exercise REFORGER 83 to maintain exercise control over the "orange" (8ID) and "blue" (3AD) forces from the corps field site at Fliegerhorst Kaserne in Hanau. V Corps would establish one CBC for each force. 8ID was expected to use SPADS to control the "orange" forces throughout the exercise. 3AD, using equipment borrowed from V Corps, would employ SPADS for the first time. The 3AD SPADS objectives were to provide friendly situation data to V Corps and to 3AD RAOC using the BIRS data base, and to pass message traffic among the 3AD main CP, 3AD RAOC, and V Corps using EMS. [Ref. 20:p. I-2]

The primary SPADS objective for Exercise Able Archer 83 was the acceptance test of the new 16-bit Corvus Concept[4]-based CGS. This new gateway had been demonstrated during REFORGER 83. A secondary objective for V Corps was to check out internal operating procedures using SPADS. [Ref. 20:p. II-1]

---

[3]The USAREUR Distributed Decision Aids System (UDDAS) introduced in March 1984 became known as SPADS II.

[4] Corvus and Corvus Concept are registered trademarks of Corvus Computers.

The primary SPADS objective for Exercise Crested Eagle 84 was to field and test the full deployment of the 16-bit communication gateway station and associated software. A secondary objective of the exercise was to evaluate a new V Corps videodisc and the new VBDS software required to integrate the video platter into the SPADS system. [Ref. 20:p. III-1]

The SPADS objectives for Exercise Caravan Guard V were to check out the software corrections or modifications that V Corps had mandated at the Exercise Crested Eagle IPR in March, and to evaluate the development of automatic graph creation that V Corps had requested during Exercise Able Archer 83. [Ref. 20:p. V-1]

The 8ID objectives for Exercise REFORGER 84 were to implement a SPADS-TACFIRE interface, use the USAREUR Distributed Decision Aids System (UDDAS) software to display the exercise information at the Umpire Control Center (UCC), and use SPADS to support the three Area Control Centers (ACC).

The primary SPADS objective for Exercise Wintex 85 was to support the V Corps CPX which consisted of the V Corps Headquarters, two division headquarters, and the 11ACR [Ref. 22:p. 7] A secondary objective was to provide the TCATA test team the opportunity to evaluate the V Corps DCP shortly after the conclusion of OC3 [Ref. 22:p. 1].

The two TCATA test issues for the evaluation during Wintex 85 were: (1) to assess the assistance provided to the commander and staff by the C2 system, and (2) to assess the assistance provided to the C2 function by SPADS and document key characteristics of that system [Ref. 22:p. 5]

Table 17 presents an overview of the exercises and objectives for OC3.

B. BOUNDING THE C2 SYSTEM

This section uses the same approach as Chapters 3 and 4. First, the workstation bounds of the hardware and software are described. Then the module level describes the SPADS entities and structure within the confines of one modular command post. Finally, the network level defines the SPADS system within the procedural, geographical, and hierarchical bounds that interconnect the modules.

1. Workstation Level Bounding

a. Hardware

Although no new hardware was introduced at the workstation level during OC3, some previously tested components were removed from the staff duty station. Neither the graphics tablet nor the joystick were rugged enough for field use and were removed without replacements.

After the successful demonstration of the ACTO mini-SDS during OC2, the decision was made that only mini-SDSs would be fielded for the remainder of the experiment. The mini-SDS had all the capabilities of the original SDS except that it could not support the VBDS functions.

b. Software

Software development during OC3 was split between upgrading older software to take advantage of the new gateway capabilities and fielding the interactive graphics software. The Data Automated Graphics and Retrieval (DAGMaR) system, introduced in 1984, provided the staff user with greater control over graphics and overlay capability. DAGMaR enabled the staff officer to link spreadsheets, data bases, and decision graphics capabilities to produce automatically updating briefing slides that could be incorporated in Current Situation.

TABLE 17
OVERVIEW OF OPERATIONAL CAPABILITY 3

	Principle Objective(s)	Date
Exercise REFORGER 83		Sept. 1983
	• 3rd Armored Division added to system • Automated data links V Corps - 8ID - 3AD • Mini Staff Duty Stations fielded • Upgraded LAN for field use	
Exercise Able Archer 83		Nov. 1983
	• 16-bit communications gateway demonstration	
Exercise Crested Eagle 84		March 1984
	• 16-bit communications gateways fielded • New video disk software demonstrated • V Corps CTOC linked through SPADS to the USAREUR Distributed Decision Aid System (UDDAS) into the CENTAG Main CP • TCT-SPADS demonstration at CENTAG	
Exercise Caravan Guard V		May 1984
	• Modifications to electronic mail system, text editor, data base management system, video battlefield display system, and communications gateway software • Implementation of TCT protocol on the 16-bit CGS • 11th Armored Cavalry Regiment added to system	
Exercise REFORGER 84		Sept. 1984
	• Integrated Data Automated Graphics and Retrieval (DAGMar) system software delivered • Implementation of TACFIRE protocol on the 16-bit CGS • 8ID Engineer/Obstacle data base implemented	
Exercise Wintex 85		March 1985
	• External evaluation of all OC3 capabilities by TCATA	

During Exercise REFORGER 83, V Corps staff users had requested the feasibility of having Briefing and Current Situation graphs automatically updated by the DBMS. With the original software, the SPADS operator had to painstakingly edit each graphic slide with every new update. DAGMar, introduced in 1984, significantly simplified the creation and updating of spreadsheet-based graphs. Once the user created

his/her fundamental graph, the program automatically generated a current version of the graph every time the data base was updated. These automatically created decision graphics were transmitted to all other modules in the network for viewing in Current Situation. [Ref. 20:p. VI-3]

The text editor and EMS were integrated during the period between REFORGER 83 and Crested Eagle 84. This integration removed unnecessary options, made the EMS functions flow more smoothly, and allowed the operator to perform all message-handling functions without leaving EMS. [Ref. 20:p. III-15]

The following corrections and enhancements were made to the EMS software immediately prior to Exercise Caravan Guard V [Ref. 20:p. III-15]:

1. Messages could be sent to more than 25 users simultaneously
2. Users could no longer create illegal volumes
3. Duplicate messages were no longer sent to addressees
4. The mail delete option was speeded up
5. Mail sent without an addressee no longer caused the gateway to stop
6. Action and information addressee were listed in "plain English" and selected addressees were printed on each message
7. An escape option was built in for use in the Read Mail option
8. More than ten modules could be addressed
9. Forwarded mail was no longer returned to the sender

A major objective of Exercise REFORGER 83 had been to use the BIRS and OB data bases for the first time to exchange friendly and enemy information among V Corps units at different echelons. During Exercise Crested Eagle 84, the two data bases were used even more, resulting in G3 Operations and G3 Plans identifying areas that required timely correction before the next exercise. The following refinements were implemented immediately before Caravan Guard V [Ref. 20:p. III-16]:

1. A global update capability was created
2. V Corps engineer data bases were developed
3. Time required to print out BIRS and OB reports was reduced
4. An "as of DTG" reporting format for BIRS and OB was added

Following Exercise REFORGER 84, V Corps SPADS users developed an updated, friendly status data base called BIRS II. This was based upon the identified requirements of G3 Operations, G3 Plans, G4 Operations, and FSE. Table 5.2 displays the BIRS II input fields [Ref. 22:p. 56]

Up until Exercise Crested Eagle 84, the text editor SPADS used was a commercially produced Pascal text editing package. SPADS users had noted recurring problems in this text editor. Additionally, the editor no longer met V Corps requirements. A new text editor was integrated with EMS. Following Exercise Crested Eagle 84, SPADS users requested the following fixes and refinements [Ref. 20:p. III-16]:

1. Eliminate the appearance of control characters within text
2. Insert a spooling capability so that all output does not go to the local printer
3. Develop a List Directory capability so that users can scan their own workspaces for file names

A secondary objective of Exercise Crested Eagle had been to evaluate a new videodisc and the associated software. The G3 staff users recommended that the following capabilities be included within VBDS as soon as possible [Ref. 20:p. III-17]:

1. Put six-digit coordinates in both VBDS and the DBMS
2. Improve the ability to "hook" units at 100 and 200 kilometers and insert a two- to five-kilometer hook radius

TABLE 18
BATTLEFIELD INFORMATION REPORTING SYSTEM II (BIRS II) INPUT FIELDS

1. UNIT:________
2. ________ 3.________ 4. TYPE:________ 5. SIZE:________
6. DATE:______Z_____ (DDHHHHZMMMYY) 7. OPCON:________
8. ENEMY ACTION:____
9. MISSION:____
10. LEAVE BLANK________
11. LEAVE BLANK________
12. LEAVE BLANK________
13. TAC CP:________

FLOT: 14.________ 15.________ 16.________
17.________ 18.________ 19.________

OPERATIONAL STATUS

1. UNIT:________ 2. DATE:______Z_____ (DDHHHHZMMMYY)

	REQ	O/H	AVL	EVAL	REASON	AS OF DAY/TIME
PERSONNEL	3. ____	4.____	5. __		6. ________	7. __/____Z
TANKS M60	8. ____	9.____	10.___	11.__	12.________	13.__/____Z
TANKS M1	14.____	15.____	16.___	17.__	18.________	19.__/____Z
CFV	20.____	21.____	22.___	23.__	24.________	25.__/____Z
DRAGON	26.____	27____	28.___	29.__	30.________	31.__/____Z
TOW LNCHR	32.____	33.____	34.___	35.__	36.________	37.__/____Z

---

1. UNIT:________ 2. DATE:______Z_____ (DDHHHHZMMMYY)

	REQ	O/H	AVL	EVAL	REASON	AS OF DAY/TIME
ATK HEL	3. ____	4.____	5. ___	6. __	7. ________	8. __/____Z
155MM HOW	9. ____	10.____	11.___	12.__	13.________	14.__/____Z
8IN HOW	15.____	16.____	17.___	18.__	19.________	20.__/____Z
MLRS	21.____	22.____	23.___	24.__	25.________	26.__/____Z
LANCE	27.____	28.____	29.___	30.__	31.________	32.__/____Z

REMARKS: 33.____
34.____
35.____

37. CDR'S OVERALL EVALUATION OF UNIT'S CAPABILITY IS:__(COLOR)
38. REASON:____

The software capabilities of SPADS were virtually completed by Caravan Guard V. DAGMaR was introduced in three stages over the next three months. The integration of DBMS, the chart editor, and the spreadsheet was accomplished by October 1984.

SPADS developed four information exchange capabilities: word processing, electronic mail, graphics, and a common data base. Word processing provided the capability to prepare, edit, update, and print text information e.g., plans and orders. Electronic mail provided the means to transmit and receive the following information within and between modules: Commander's estimate, FRAGO, FLOTREP, SITREP, OPORD, INTSUM, SPOTREP and Weather. The graphics data were stored locally; the overlay data, which were superimposed on graphic data or videodisc-generated maps, were transmitted within and between modules. The common data base at each module was partitioned according to staff/echelon functions; users input data into their partitioned area of the common data base; and the input data was automatically replicated in common data bases at other module locations.

These information exchange capabilities were supported by the following software capabilities of SPADS. BIRS gave the SPADS users information on friendly units and was available through the DBMS at all staff duty stations. Similarly, OB provided information on enemy units for all users. EMS provided intra- and inter-module text transfer for all SPADS users. VBDS was available at one SDS in each module to provide display of friendly and enemy force data and situation. Spreadsheet provided processing for worksheet calculations and transmission for all users. Current Situation was available at every SDS. DAGMaR provided decision support by integrating the DBMS, spreadsheet, and decision graphics at all staff duty stations. [Ref. 19:p. 50]

In addition, SPADS developed five decision support capabilities during the three operational capabilities. A relational database management system provided the means to extract information from large data files by querying of a single file or across multiple files. The correlation of geographically indexed reports and data bases with map backgrounds provided the capability to automatically display data such as unit locations on a single overlay of specially prepared maps shown on the color monitor. Map-to-photo correlation allowed quick retrieval of photographs stored on the videodisc by pinpointing the location of the desired photograph on the map display being viewed through a series of crosshair overlays. Spreadsheet models provided the means to perform mathematical calculations related to status monitoring and projection. The execution of functional area algorithms supported individual staff functions such as maneuver, combat service support, target planning, and force comparison.

2. Module Level Bounding

a. Hardware

The significant advancement at the module level was the introduction of the 16-bit communications gateway station. The 16-bit gateway was demonstrated during Exercise REFORGER 83 and successfully underwent acceptance testing during Exercise Able Archer 83. Prior to Exercise Crested Eagle 84 all SPADS Apple II+ 8-bit gateways were replaced by the new 16-bit Corvus Concept-based gateways. The new gateway implementation followed the seven layer ISO-OSI model. Table 19 presents an overview of the SPADS implementation of this model [Ref. 20:p. II-5].

TABLE 19
SPADS IMPLEMENTATION OF THE ISO-OSI MODEL

Seven Layers of ISO-OSI	SPADS Protocol
7. Application	Mail, File Transfer, Data Base Update
6. Presentation	Conversion to network format; End delivery
5. Session	Login Validation
4 Transport	- - -
3. Network	Message Switching
2. Link	Variable Frame Size; Windowing; CRC checksum
1. Physical	RS232 Asynchronous

The new gateway controlled the local network within a module and provided users with the capability to send both messages and files to other users within the module or to users in other modules via the tactical communications system. The components of the new gateway were [Ref. 20:pp. III-3, III-6]:

1. Two Corvus Concept 16-bit microcomputers
2. A modem for each communication link (one microcomputer could handle up to four links)
3. An 8-inch floppy disk drive
4. A full function keyboard
5. A monitor with a video switch that permitted viewing of either microcomputer's contribution to the CGS
6. Two cases that permitted operating the equipment without removing it from the cases and that provided protection for the equipment when it was transported

One of the microcomputers controlled the module network and was called the network control processor (NCP). The other microcomputer provided the communications interface and was called the communications link processor (CLiP); the CLiP supported four external data links.

The new gateway hardware alleviated the following problems and weaknesses in the old Apple II+ CGS [Ref. 20:p. III-6]:

1. Excessive size and weight
2. Excessive hard disk accesses for program chaining and polling for files
3. Inadequate queuing for files
4. Nearly full processing and memory capacities

The 16-bit gateway was one third the size and one fourth the weight of the old gateway. Hard disk accesses were reduced by 70 to 80 percent. Improved file queuing resulted in reduced system manager intervention and the prevention of message loss. Approximately 50 percent of the processing capacity and 30 percent of the memory capacity were in use on the new CGS, as opposed to both capacities being nearly 100 percent full on the older gateway. [Ref. 20:p. III-6]

The Apple equipment that was recovered from the older gateways was retrofitted to create 26 mini-staff duty stations, four shared output stations and two mass storage stations. The resulting configurations were placed in the 3AD and the 11ACR to provide complete interconnectivity for the V Corps DCP. [Ref. 20:pp. III-6, III-14]

Table 20 presents an overview of the hardware components of the 16-bit communications gateway station.

TABLE 20
16-BIT COMMUNICATIONS GATEWAY STATION (CGS) HARDWARE

Microcomputer	Corvus Concept I (One each for NCP and CLiP)
Processor	Motorola MC-68000 • 32 bit data • 24 bit memory • 16 bit data bus
Memory	256K Expandable to 1 Mbyte
Interfaces	RS-232C 19,2000 baud RS-422 1 Mil baud
Monitor	15 inch CRT, • 35 MHz • Bit mapped display
Floppy Drive	8 inch 1 Mbyte
Detached keyboard	
Modem	Racal-Vadic (up to four per CLiP)
External connections	Four 2-wire connections
Universal power supply	Supports microcomputers, monitor and modems

b. Software

The three major functions of the new gateway were an upgraded EMS, new common area management, and substantially more powerful network management. The new EMS selected routing, prepared headers, sent messages and packages to authorized users, received and analyzed messages, and delivered messages and packages to authorized users. The common area management (CAM) automatically updated common area within

the local network, routed updates to remote modules, and allowed users read-only access to common area volumes of all authorized users. The network management administered user access to the network, administered the network topology, provided statistical monitoring or network usage, and performed user service requests. [Ref. 20:p. III-14]

Figure 5.2 displays an overview of the three functional areas of the communications gateway station [Ref. 20:p. III-8].

During Exercise Crested Eagle 84, SPADS system managers identified the following problems with the NCP code [Ref. 20:p. III-17]:

1. The NCP sometimes stopped and/or fatally crashed when processing BIRS and OB updates
2. The NCP needed a distinct audio or visual alarm to signal fatal errors
3. A capability was required to automatically reinstate users when the NCP was restarted after stopping

By the end of Exercise Caravan Guard V all but six of the software modifications mandated by V Corps had been installed. The most significant remaining modifications related to the number of staff duty stations that could be logged onto a local network and the number of total modules permitted in the network. Up to this time, V Corps could only connect ten SDSs to a local network and ten CGSs to the global network. The final modifications increased the number of users in the global network to 10,000, the only restriction being that a maximum of 255 staff duty stations could be logged on the LAN. This increase, together with the elimination of restrictions pertaining to the number of modules, provided V Corps with immense flexibility for employing SPADS in future configurations. [Ref. 20:p. VI-12]

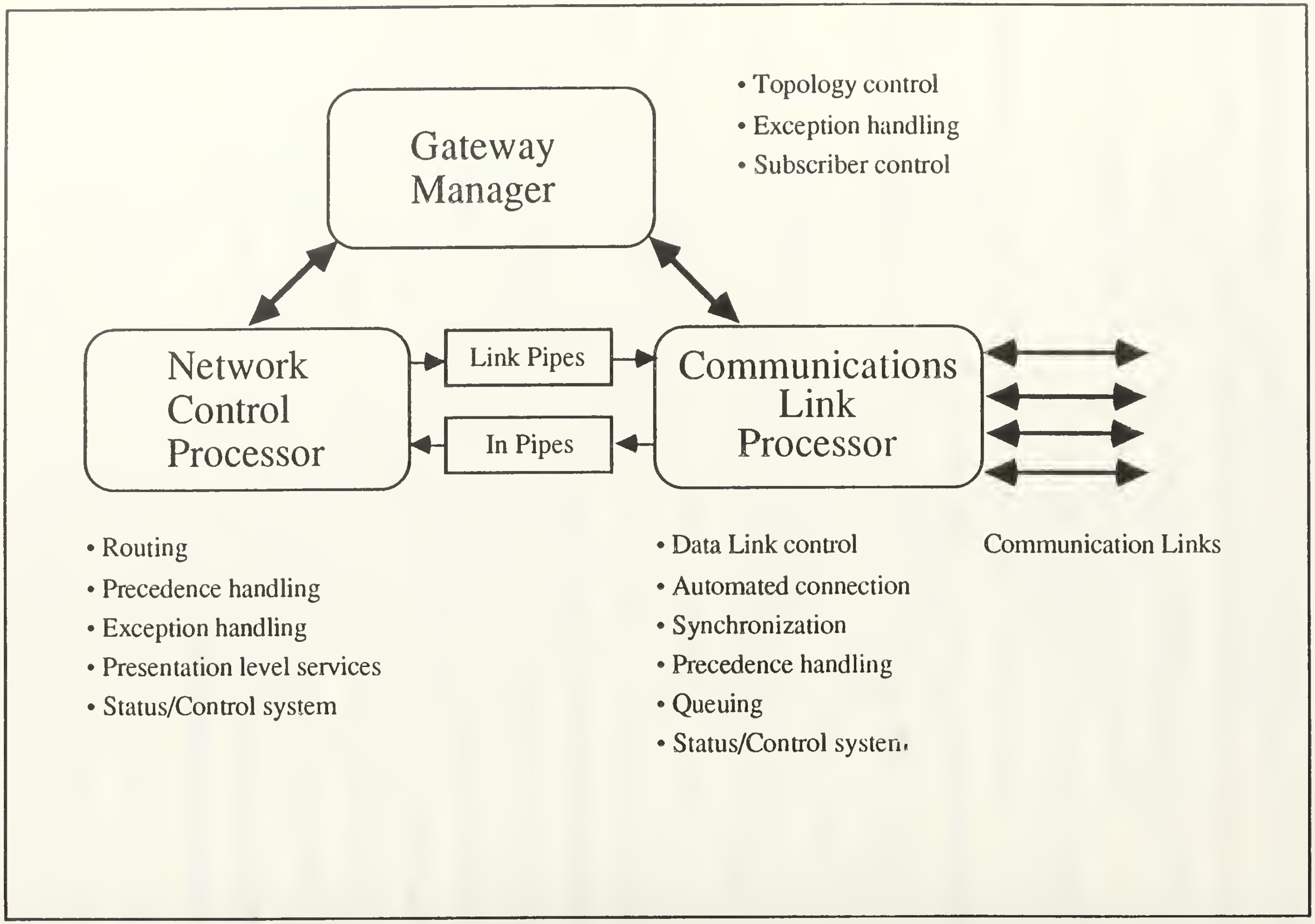

Figure 5.2. Communications Gateway Station Functional Diagram

Following Exercise REFORGER 84 two final upgrades were made to the gateway software [Ref. 20:p. VI-14]:

1. An Initializer was introduced that replaced the Gateway Manager and ran on the same microcomputer as the NCP
2. Modifications were made to the NCP and the CLiP that resulted in full, TCT free text message interface with SPADS, allowed up to four CLiPs per module (permitting 16 external communications links), and moved the overflow and queuing functions from the CLiP to the NCP.

3. Network Level Bounding

Based upon the new gateways and the dispersal of equipment to 3AD and 11ACR, the V Corps DCP had spread throughout its entire geographic area and had established interconnectivity from the USAREUR/CENTAG level down to its principal combat units. Figure 5.3 displays the V Corps SPADS network that was possible during OC3.

4. Economic Bounding

The total funding for SPADS through FY 84 had been $7.2 million. Table 21 presents an overview of both the equipment costs and contractor support costs during OC3[5].

C. C2 SYSTEM ARCHITECTURE

1. Workstation Level Integration

During OC3 only one new software implementation produced new opportunities for staff interaction. However, since DAGMaR capabilities were gradually phased into SPADS, the spreadsheet and DAGMaR can be considered two separate functions. The next two figures present the integration of the two new software functions with the C2

---

[5] Interview with LTC Laird, 17-18 December 1987.

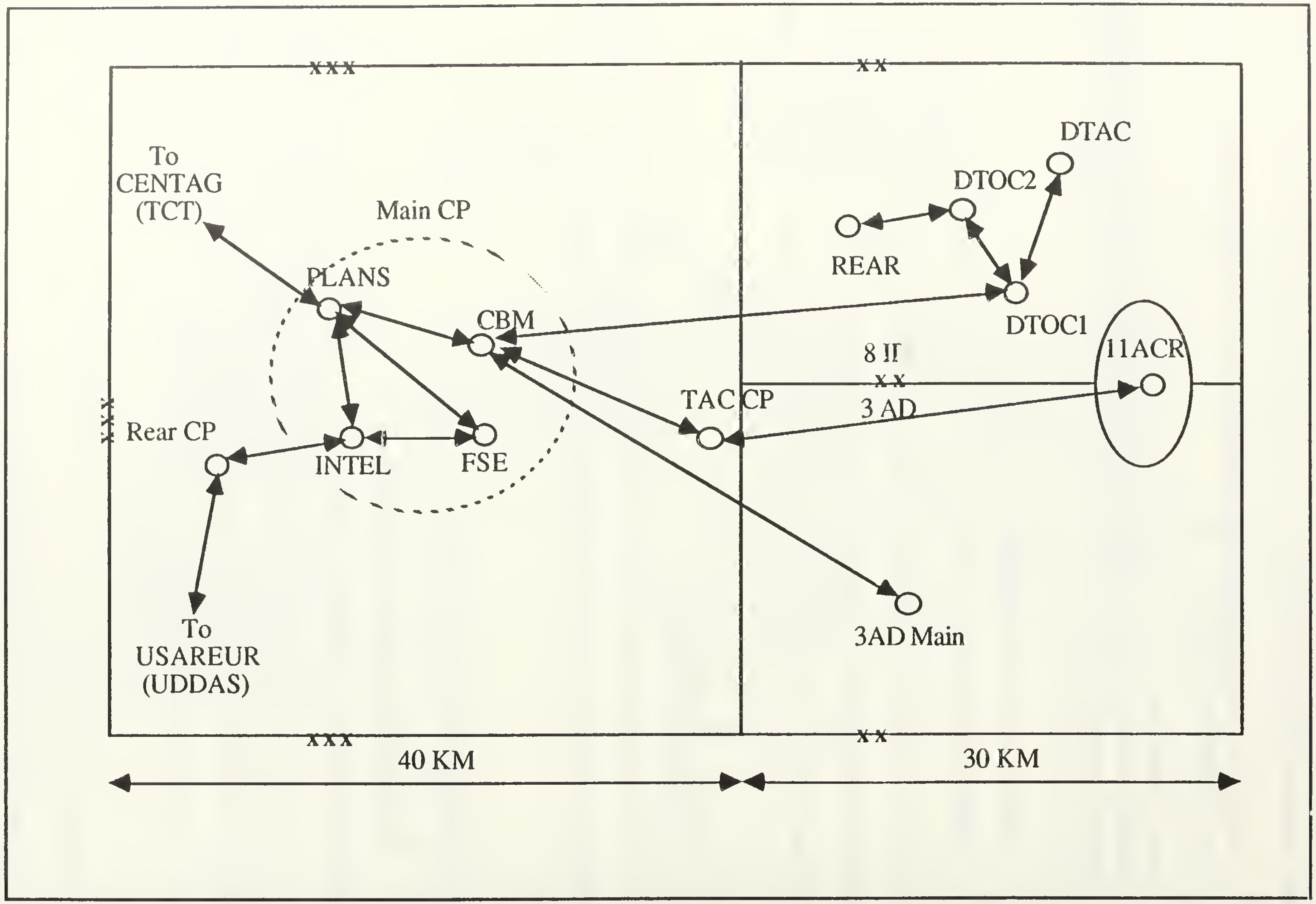

Figure 5.3. SPADS Network During OC3

TABLE 21
ECONOMIC BOUNDING DURING
OPERATIONAL CAPABILITY 3

EQUIPMENT COSTS

16-Bit Communications Gateway Station	$12,230.00
Staff Duty Stations	
• SDS with Video Package	$11,800.00
• SDS without Video Package	$ 5,860.00
• Mini SDS with Medium Speed Printer	$ 5,640.00
Mass Storage Stations	
• Large Package 20 MByte Hard disk	$ 8,050.00
• Small Package 20 Mbyte Hard disk	$ 5,750.00

CONTRACTOR SUPPORT COSTS

Exercise support per week per contractor (Europe)	$ 2,547.00
Maintenance of System	10% of Component Costs
Maintenance support per week per technician (Europe)	$ 1,007.00
Module Transportation Costs (Approx. $10/pound to Europe)	$ 900.00

TOTAL FUNDING THROUGH FY 84 $7.2 million

system and the C2 process. First, figure 5.4 displays the integration of system, process, and function with the spreadsheet. Then figure 5.5 shows the integration of entities, structure, and functions with DAGMaR.

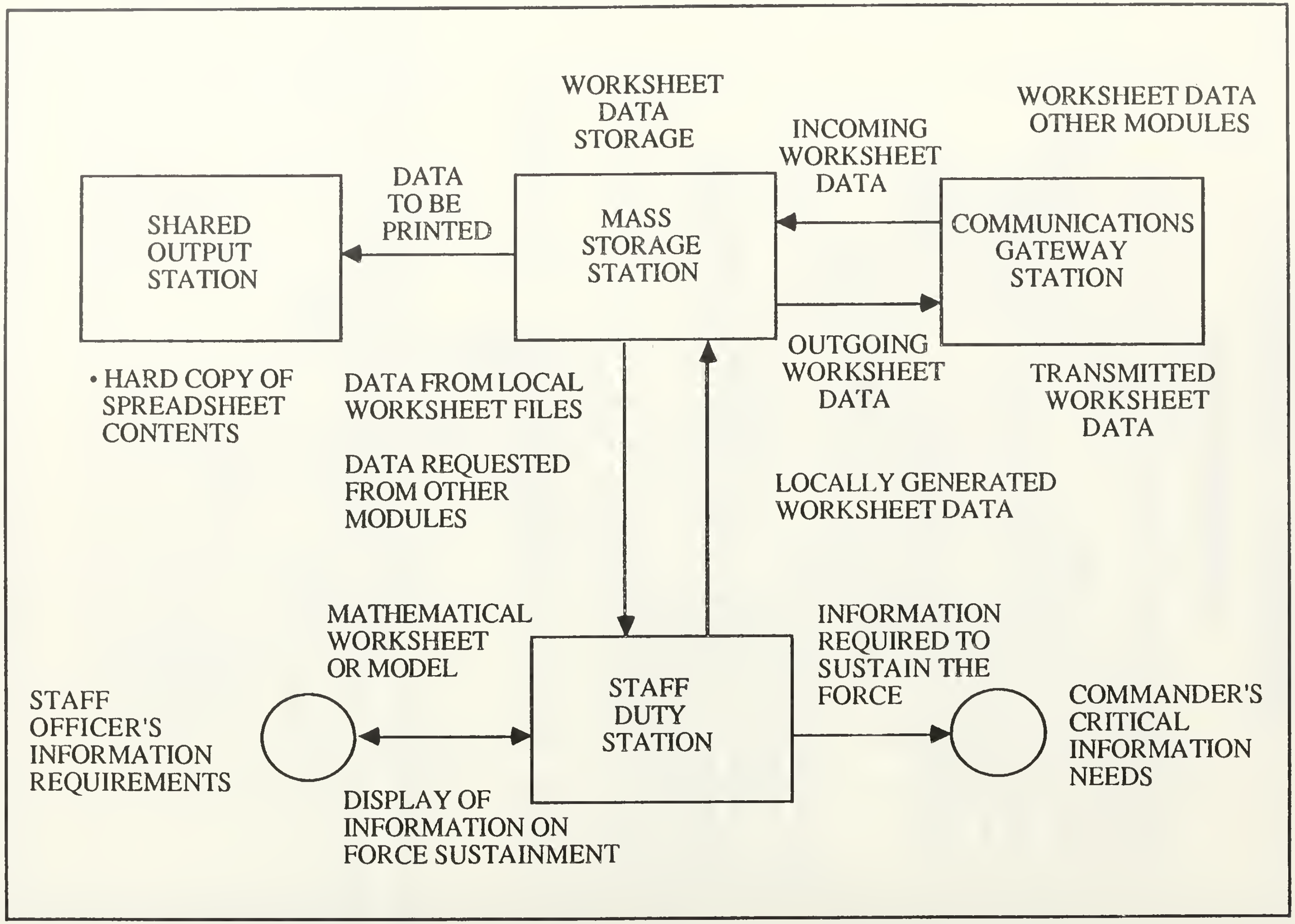

Figure 5.4. Integration of Spreadsheet

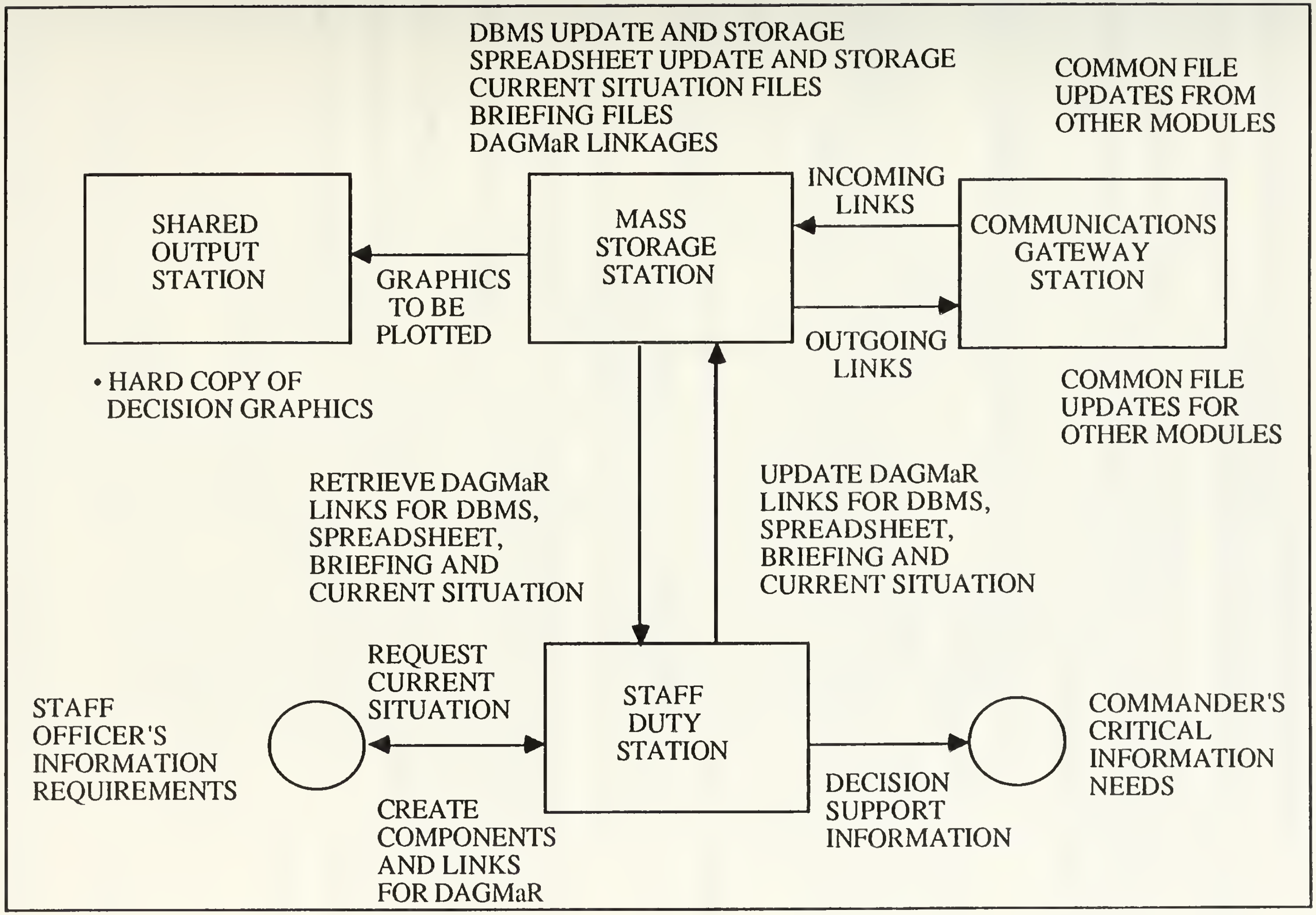

Figure 5.5. Integration of Data Automated Graphics Manufacture and Retrieval

2. Module Level Integration

The gateway had a strong integrating influence on the C2 process and functions at the module level. The concept of the Network Monitor Station (NMS) was introduced late in OC3 to further cement the unifying concept of the gateway and the mass storage station as one logical entity. Up to 16 staff duty stations would be supported by one NMS under this plan. [Ref. 6:p. F-1]

The V Corps G3 Operations clarified the role of SPADS equipment within a DCP module [Ref. 6:p. F-1]:

> The most important function of SPADS is the automatic distribution of threat order of battle and friendly operational databases [sic]....any staff officer/NCO can get instant data and video graphics on any unit and its situation (friendly and enemy) that has been reported via SPADS without contacting the unit with an individual request.

Figure 5.6 represents the integrating influence of the SPADS Protocol Architecture. This figure displays the ISO functional model vis-a-vis the SPADS hardware, software, and staff user applications. [Ref. 20:p. II-6]

Despite their broad outlook, the DNA and Army agencies supporting the DCP never foresaw the new implementations that the V Corps and 8ID SPADS users would create to overcome operational difficulties in Germany. The last exercise of OC3, REFORGER 84, gives an example of this environment. 8ID was supposed to apply Umpire and Exercise control over the VII Corps field exercise. The following paragraphs describe their unorthodox application of SPADS and TACFIRE to fulfill their responsibilities.

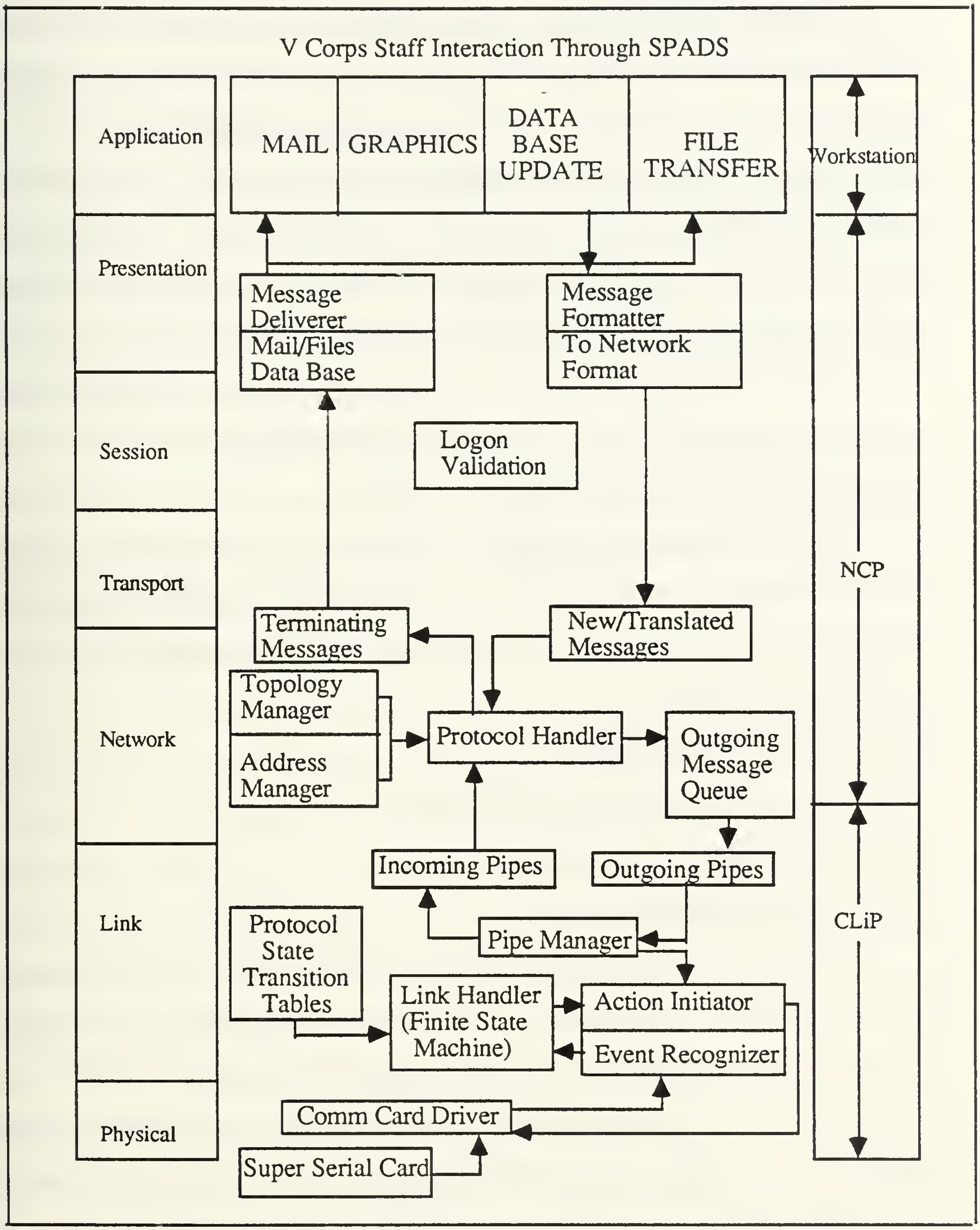

Figure 5.6. Integration via the SPADS Protocol Architecture

In their role as umpires, 8ID had wanted to use TACFIRE to keep track of umpire-reported unit and obstacle locations and to use this data in conjunction with other exercise data to develop briefings. They had also wanted to use USAREUR's DAViD with a large screen and video projector to display the exercise situation. DAViD had been developed for UDDAS; UDDAS was also known as SPADS II because of its similarities to SPADS. DAViD performed the same functions as the V Corps VBDS but provided significant enhancements in that symbols, data base relations, and display features were all user definable. The 8ID needed the SPADS II workstations to run DAViD; these workstations consisted of Corvus Concept 16-bit microcomputers and advanced high-resolution graphics devices. [Ref. 20:pp. VI-1, VI-2]

The 8ID objectives for REFORGER 84 were to use their newly developed TACFIRE interface, DAViD, SPADS II, and SPADS to support umpires throughout the exercise area. This concept of operations included four capabilities not previously used by the 8ID [Ref. 20:p. VI-8]:

(1) The TACFIRE interface

(2) The DAViD-generated large screen display

(3) The SPADS II workstations

(4) An engineer obstacle data base

The most unorthodox part of their solution was the selection of two systems that had not previously been interconnected. After 8ID initiated its statement of work for the TACFIRE interface, significant coordination occurred between the TACFIRE Project Manager in CECOM, the Field Artillery School at Fort Sill, and the developer to develop the software for the interface and to select an appropriate modem for the hardwire interface. A synchronous circuit card had to be designed for the gateway microcomputer.

Appropriate software had to be developed that handled the Hamming code scheme used in TACFIRE for error detection and correction during data transmission. [Ref. 20:pp. VI-9 - VI-10]

3. Network Level Architecture

Unlike the second operational capability, OC3 focused on accomplishment at the network level. The fielding of the new gateway during Exercise Crested Eagle 84 dramatically accelerated V Corps DCP integration. The ingenuity of operational planners and users produced a greater interconnectivity than that conceived by the DNA or other financial supporters of the DCP experiment.

The two perspectives to examining OC3 are connectivity and structure. OC3 marked the successful network interconnections from CENTAG and USAREUR down to the corps maneuver elements. During this same period V Corps finally attempted to integrate SPADS into the C2 structure.

a. SPADS Connectivity

With the advent of the new gateway, V Corps had the opportunity to experiment with connectivity between different generations of gateways. V Corps did not deploy to the field during Exercise Able Archer 83, but set up five modules at the headquarters in Frankfurt. The new CGS was used in the CBC module. The Intel, FSE, Plans, and Rear modules all used the older gateway. All modules were interconnected through TASS, set up outside of the headquarters, to successfully communicate among the modules. [Ref. 20:p. II-1]

During Exercise Crested Eagle 84 the CENTAG main CP used the newly developed UDDAS. In addition to its intra-CP connections, it also established communication links to V Corps through SPADS via their respective communication gateways. Electronic mail traffic was passed between the systems. [Ref. 20:p. III-3]

Following Exercise Crested Eagle 84, the earlier Apple gateways had been converted to new equipment for V Corps maneuver units. One SPADS module, with one gateway and one staff duty station, was installed for the 11ACR during Caravan Guard V. The 11ACR started with one small module to allow staff to learn the system during the exercise. They were to have an active role in a highly dynamic field exercise. Two SPADS modules, each with one gateway and two staff duty stations, were installed for 3AD. 3AD had used SPADS, borrowing equipment from V Corps, in two previous exercises, REFORGER 83 and Crested Eagle 84. [Ref. 21:pp. V-1 - V-2]

The concept of operations for Exercise REFORGER 84 was for 8ID umpires at field locations to enter unit and obstacle locations into SPADS data bases. Umpires used the TACFIRE Digital Message Device (DMD) and single channel FM radios to enter data into the TACFIRE computer at the UCC. This computer passed the data to SPADS via the hardwire interface from TACFIRE to SPADS. The UCC SPADS module then updated the ACC data bases via the gateways at each ACC module. The data were used to generate various reports and briefings using SPADS and SPADS II capabilities. In particular, the data were used to automatically generate large screen displays of the blue and orange forces with DAViD, using SPADS II workstations. [Ref. 20:pp. VI-2 - VI-8]

The objectives for this exercise were met and exceeded. When 8ID was tasked to provide exercise support for REFORGER 84, they had no automated capability to process the data that umpires entered into the TACFIRE computer via the DMDs or to display that data for situation briefings. They did have the SPADS system and had used SPADS with varying degrees of success during several exercises. The TACFIRE interface, the obstacle data base, and the use of DAViD in conjunction with a large screen display, all integrated to work with the 8ID SPADS system, providing them with the

required capabilities. This integration demonstrated the adaptability and ingenuity of the operational planners and users of SPADS. [Ref. 20:p. VI-14]

Fewer SPADS problems occurred during Exercise REFORGER 84 than in previous exercises despite the integration of new concepts and capabilities. Three primary factors contributed to 8ID having an extremely successful exercise [Ref. 20:pp. VI-14 -VI-15]:

1. Detailed planning began three months prior to deployment
2. Adequate time was set aside for training without conflicts from other activities
3. A thorough equipment check-out was conducted prior to leaving for the field locations.

V Corps and its subordinate units had assigned each of these three factors varying degrees of importance throughout the three operational capability cycles—this inconsistency resulted in widely divergent degrees of success. The highly successful results of Exercise REFORGER 84 proved the value of giving each of these factors a high degree of emphasis. V Corps SPADS users and planners should have seen these successes as a further demonstration of the best direction toward self-sufficiency. [Ref. 20:p VI -15]

b. Structure

DNA was particularly interested in the successful transition of V Corps to self-sufficiency before the completion of the contract at the end of FY 84. Following the Caravan Guard V IPR, V Corps gradually started the necessary action to establish a dedicated section to plan, train, and support the deployment and operation of SPADS at V Corps. [Ref. 11:p. V-3]

A decision briefing was presented to the V Corps commander on 21 November 1983 regarding the missions, goals, functions, and organization of the proposed Command and Control Initiatives Office (C2IO) [Ref. 23:pp. 1-10]. All recommendations were approved. Requirements for officers to staff this new organization were delivered to the

ACofS, G1, on 13 December 1983. These officers had already been interviewed by the newly appointed C2 Initiatives Officer in late October and early November (prior to the decision briefing). Political infighting stalled the original assignments and certain substitutions had to be accepted by the end of December.

The C2IO was to have two sections—each consisting of four officers and one NCO—supervised by the C2 Initiatives Officer. The functions of each section are presented in Table 22. The C2IO was activated 1 January 1984 for a period of one year. By 1 January 1985, the C2IO was supposed to have established a long-term program for the automation of the V Corps C functions, including logistical support and sustainment training for evolutionary C2 systems. [Ref. 24:Incl 3]

The broad missions of the C2IO were to: coordinate all tactical C2 initiative functions in V Corps, including developmental systems; SPADS applications to peacetime management information requirements; and C2 developmental system sustainment and evolutionary growth. The goals of the C2IO were to: finalize the V Corps DCP concept and the current technical baseline for SPADS; install and maintain a non-secure SPADS system in the peacetime headquarters that could be readily transitioned to the wartime configuration; provide sustainment functions, including user training, staff assistance for application development, and system troubleshooting and maintenance; develop a V Corps C2 master plan; and identify the V Corps Management System (VCMS) automation requirements and prepare documentation to support acquisition of additional assets. [Ref. 24:pp. 1-2]

TABLE 22
FUNCTIONS OF THE COMMAND AND CONTROL INITIATIVES OFFICE

PLANS AND OPERATIONS	SYSTEMS
• Requirements identification	• Program planning
• Concept formulation	• System architecture planning
• Exercise plans and operations	• Configuration control
• Field evaluation planning	• Training plans and coordination
• Test planning	• User's documentation
• Develop operational procedures	• Property accountability

Joint Section Responsibilities

- Contract Direction
- SPADS Staff Training
- Data Base and Applications Development
- Coordination with Other Commands:
  - USAREUR DCSOPS C3I
  - Defense Nuclear Agency
  - Combat Development Activity (CACDA)
  - Material Development Activity (CECOM)
  - V Corps Major Subordinate Commands (3AD, 8ID, 11ACR, 3rd SUPCOM)

The ACofS, G3, was the proponent for the organization and operation of the V Corps command posts and for the fielding of the Maneuver Control System (MCS) within V Corps. The C2IO was the proponent for the microcomputer-based C2 systems at the different echelons of the corps CPs, and was responsible for integrating the MCS into the

overall corps C2 network. The automation management officer (AMO) was the proponent for "Battlefield Automation Management"; the C2IO was responsible for keeping the AMO advised of tactical C2 system planning and system actions. Finally, the C2IO was to establish a program for automation of the VCMS in coordination with the ACofS, Resource Management. [Ref. 24:Incl. 3]

There had been an absence of specific SPADS objectives for each exercise during the first thirteen tasks of the SOW. One result of the creation of the C2IO was the development of specific, measurable SPADS objectives for each exercise that occurred during the last ten tasks. [Ref. 20:p. 3]

The software accomplishments that occurred during the last ten tasks were the result of a concerted effort by the C2IO to implement only those refinements and enhancements that met mission-essential C2 functions. The significant software modifications during this period were in response to requirements—identified by the C2IO during Exercise Crested Eagle 84—for the communications gateway software and the decision graphics package. [Ref. 20:pp. 7-8]

The SPADS objectives for Exercise Crested Eagle were to install the new gateway in all DCP modules as well as evaluate the new videodisc and VBDS software. C2IO members aggressively tested and validated the software and made a concerted effort to identify shortfalls, refinements, and enhancements for SPADS. C2IO officers mandated 21 modifications to the SPADS software for OC3. These modifications involved the EMS, text editor, DBMS, VBDS, CAM and NCP software. [Ref. 20:p. 8]

Lack of a comprehensive training management program in the past had caused operational problems during nearly every exercise. In addition, because corps staff users and decision makers never recognized the power and potential of SPADS, the system had not been integrated into the corps C2 processes. Staff officers and NCOs who were

performing C2 functions were not aware of SPADS capabilities, while previously trained operators and system managers were not involved in C2 functions. And neither the data bases nor their uses had been refined from OC1 through the close of OC3. These factors had all adversely affected V Corps staff user attitudes and the integration of SPADS C2 functions. [Ref. 20:p. 10]

This counterproductive situation improved sharply when the C2IO began a systematic training program which was managed, planned, and conducted by V Corps personnel. This program supported only the V Corps exercise objectives identified by the C2IO. Training was scheduled well in advance of exercises. The number of trainees from each staff section was based on the needs of the command posts. Periodic refresher training was mandated for all personnel. Finally, follow-up training was scheduled after exercises.

Parallel to the improvement in training was a concerted C2IO effort to improve the SPADS documentation. The documentation included several versions of the Operator's Manual, a System Manager's Manual, and a Staff Officer's Manual. These manuals varied greatly in quality, ranging from the slickly produced Staff Officer's Manual to the wholly inadequate System Manager's Manual. The Operator's Manual, for example, contained out-of-date instructions for each of the SPADS capabilities as well as obsolete descriptions of the hardware, software and system.

The System Manager's Manual was outdated as soon as the Corvus-based gateway superceded the Apple II+ CGS. The C2IO produced a timely and concise version of the System Manager's Manual before Exercise Crested Eagle. Changes updating the Operator's Manual were ready in advance of Exercise Caravan Guard V in May 1984. Almost up-to-date versions of both manuals were finally delivered by the developer at the end of OC3. [Ref. 20:pp. 11-12]

The developer delivered six of the last 21 software modifications shortly before Exercise Caravan Guard V. The C2IO received a short, but intense, familiarization session on these changes, prepared updated training materials, and conducted training for V Corps personnel. The Caravan Guard V IPR noted that "Fewer SPADS problems occurred during this exercise than in any previous exercise." [Ref. 20:p. 12]

The next major step V Corps took was to distribute the V Corps Dispersed Command Post LOI in 1985. This document provided instructions for the DCP configuration, listed module and staff section responsibilities, established authorized equipment levels, and dictated that SPADS was to be used as the V Corps C2 system for all exercises. The LOI presented an honest appraisal of the employment constraints of and the threats to the V Corps DCP. It specifically waived the requirement for a ten-kilometer dispersal between main CP modules [Ref. 5:p. 2]:

> With the current V Corps communications equipment and assets the modules of the main CP can not [sic] be dispersed further than 1200 feet from the Signal Center.

It further stated that this critical survivability requirement would not be met until some unspecified future time [Ref. 5:p. 2]:

> ...the concept of a modularized, dispersed command post which cannot be dispersed until the introduction of Mobile Subscriber Equipment (MSE) communications network. This system will give each module its own signal center and allow true dispersed operations.

Figure 5.7 displays the V Corps DCP constrained by communications equipment in the mid-1980s. It also presents the SPADS staff duty station and gateway assignments for the six modules that made up the V Corps DCP. Figure 5.8 shows the planned V Corps DCP employment after the corps received the new Mobile Subscriber Equipment.

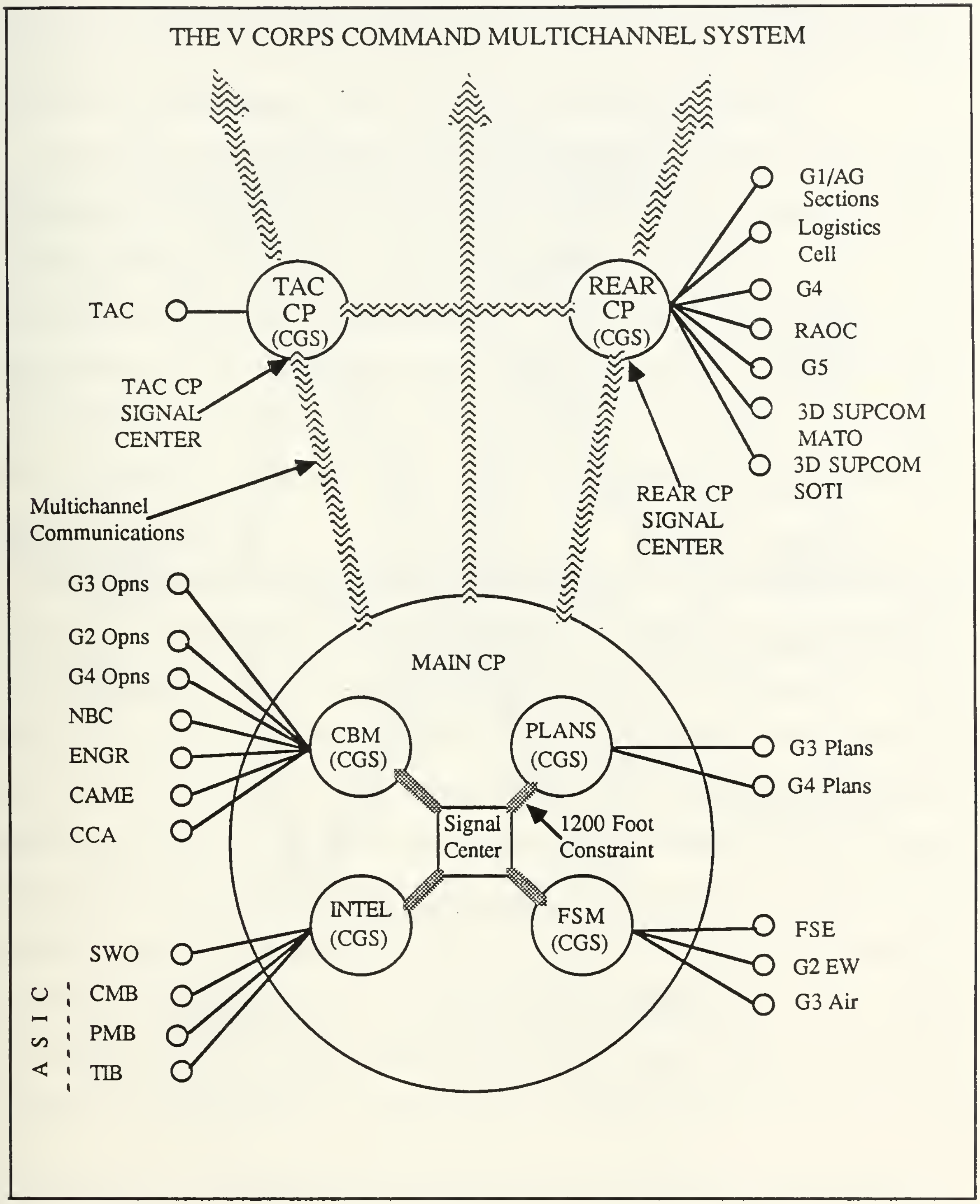

Figure 5.7. V Corps DCP Employment (Communications Restrained)

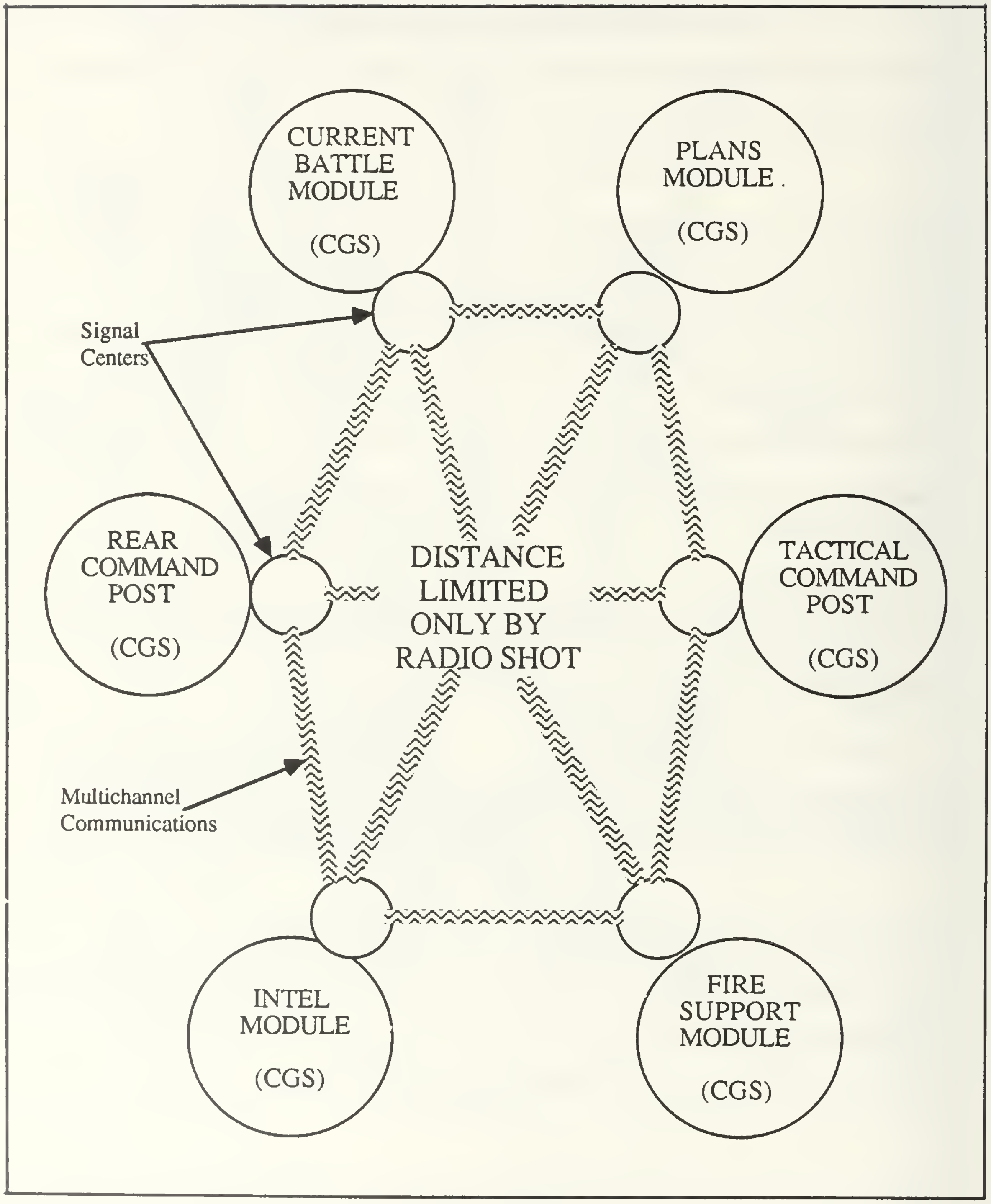

Figure 5.8. V Corps DCP Employment (Mobile Suscriber Equipment)

D. DATA GENERATION

The data generated for the five exercises of OC3 are shown in Table 23[6]. The data generation worksheet and formulas discussed in Chapter II were used to produce values for this OC. The means for each evaluation category are displayed in Figure 5.9.

As an aid to better understanding of SPADS and the V Corps DCP employment, three additional evaluations were conducted after OC3. The first was an evaluation of Wintex 85; during this exercise TCATA conducted the last formal evaluation of SPADS. The next two evaluations were scenarios based upon the V Corps DCP LOI. The second evaluation was conducted with the dispersal constrained by the communications. The final evaluation was conducted with full MSE support of the V Corps DCP. The data generated for these three evaluations are shown in Table 24[7] . The means for each evaluation category are displayed in Figure 5.10.

A brief review of the data generation procedures from Chapter II are presented in this paragraph. After action and lessons learned reports were collected from V Corps, DNA, and the developer for each exercise during this final operational capability cycle. The V Corps DCP LOI was the source of data for the two scenarios. Values were determined for every measure from each exercise using the worksheet, definitions, and procedures specified in Chapter II. The measures were individually considered as binary conditions for each DCP module that participated in the exercise or scenario under consideration. The summed measures (e.g., FAIR, XMOTi, and XCSTi) received their cumulative, unweighted scores based upon their constituent measures of performance or effectiverness. The final measure, C2/FE, was calculated in accordance with the procedure specified in Chapter II. The results for each exercise are displayed in Table 23, and the

---

[6] The following sources provided raw data for the final three evaluations: Ref. 22 (Wintex 85) and Ref. 6 (V Corps DCP LOI-based scenarios).

TABLE 23
DATA GENERATED FOR EACH EXERCISE DURING OC3

Measurement Categories	REFORGER 83	Able Archer 83	Crested Eagle 84	Caravan Guard IV	REFORGER 84
FAIR	28	42	32	33	20
Timeliness	7	6	6	7	7
Capacity	7	6	6	9	4
XMOTi	**42**	**54**	**44**	**49**	**28**
Dispersion	8	0	6	8	15
Redundancy	0	6	16	14	8
Continuity of Operations	14	12	16	15	8
XCSTi	**22**	**18**	**38**	**37**	**31**
C2/FE	**64**	**72**	**82**	**86**	**59**

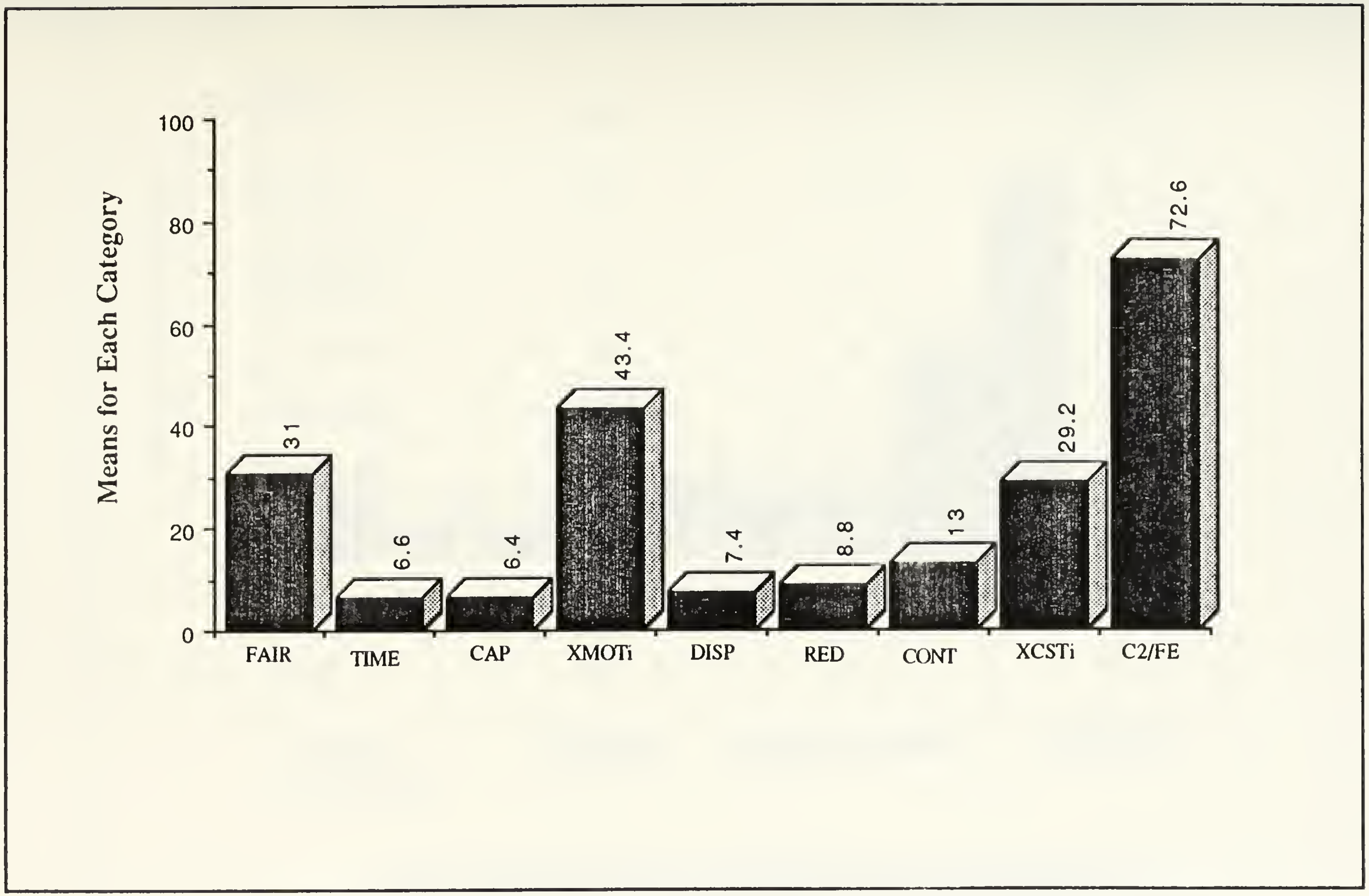

Figure 5.9. Means for Each Category During OC3

TABLE 24
DATA GENERATED FOR EVALUATIONS BEYOND OC3

Measurement Categories	Wintex 85	DCP (Constrained)	DCP (MSE)
FAIR	18	18	18
Timeliness	6	9	9
Capacity	6	9	9
XMOTi	**30**	**36**	**36**
Dispersion	2	10	39
Redundancy	5	18	18
Continuity of Operations	6	18	18
XCSTi	**13**	**46**	**75**
C2/FE	**43**	**82**	**111**

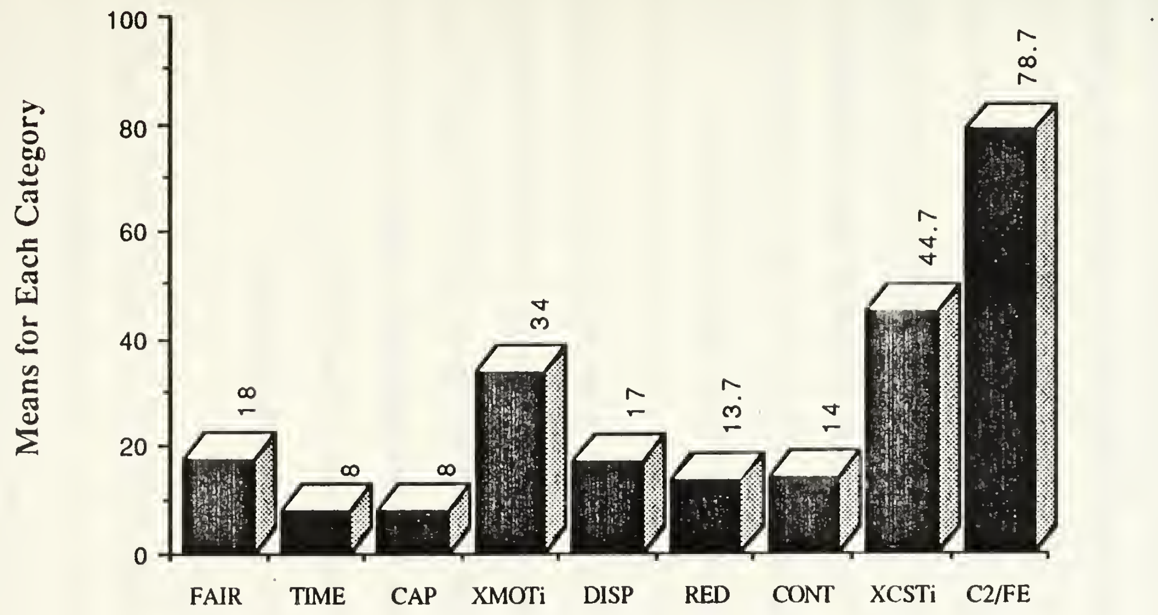

Figure 5.10. Means for Each Category in the Three Scenarios

means for each evaluation during OC3 are shown in Figure 5.9. The results for the final three evaluations are presented in Table 24, and the means for these evaluations are shown in Figure 5.10.

E. AGGREGATION AND INTERPRETATION OF MEASURES

Once again, After Action and Lessons Learned Reports contained a great deal of data and were extremely helpful in understanding the characteristics of the experiments during the exercises.

1. C2 Mission Orientation

The value of C2 Mission Orientation, XMOTi, begins at approximately the same level as OC2, rises slightly and then gradually recedes until the end of OC3. There was a measurable loss in effectiveness by the end of the experiment period. The following three sections interpret the three components of C2 Mission Orientation.

a. C2 Process

There was a sharp loss in functionality during OC3 from the Caravan Guard V to the end of the experiment. While the functions of the V Corps commander and staff may have remained constant, the DCP environment and SPADS, in particular, caused a gradual decrease in the commander's and staff's abilities to exercise command and control of the corps. The flat response during the three additional observations may represent the C2 process steady state in a resource-constrained environment.

b. Physical Entities

Physical entities continued to change during OC3. Some new software was introduced, and refinements were continually made to established software functions. The new communications gateway package was integrated into the DCP environment. The value of capacity reached a three-year high during Exercise Caravan Guard V. With the fielding of the upgraded CGS throughout the V Corps DCP, the system's capacity reached

a new level. The last two evaluations sustained the same level of capacity as Exercise Caravan Guard V.

c. Structural Components

The value of the structural measure modulates gradually throughout OC3. SPADS was able to consistently accomplish the transmission of *critical information required by the commander* . Although more traffic was generated during each exercise, SPADS was able to consistently provide the V Corps commander with dependable, critical, decision making information. Theoretically, the values of timeliness reached a higher state during the last two evaluations than during the previous three operational capability cycles.

2. Command Survivability

SPADS made more progress towards consistently achieving command survivability during OC3. Except for the first two command post exercises, dispersion between modules gradually increased and more modules were added to the corps system. The low value for the next-to-last evaluation reflects an honest appraisal of the communications-constrained environment. Conversely, the final measure represents the highest possible value possible using MSE. Defying the trends from OC1 and OC2, significant progress was made toward redundancy; this can be specifically related to new command influence and staff orientation. The values in the final two evaluations represent an ideal redundant environment. Finally, the values of reliability and transportability rise slowly to the high points of Crested Eagle 84 and Caravan Guard V. Like redundancy, the last two values represent an ideal state for continuity of operations.

3. C2 Force Effectiveness

SPADS did evolve during OC3 based upon the operational lessons learned. The evolution involved hardware, software, protocols, and communications interfaces. SPADS reaches new high values for C2/FE and only gradually declined when it entered a

highly constrained, resource-depleted environment after all sponsors stopped funding at the end of OC3. SPADS was becoming institutionalized within the V Corps C2 structure; unfortunately, the creation of the C2IO and the distribution of the DCP LOI occurred in a period when no sustaining resources were available. The potential values of C2/FE rise distinctly when V Corps was forced to take maximum advantage from their automated C2 system. The value of C2/FE could nearly double in value, compared to the start of OC3, if the V Corps DCP is employed in an MSE-supported environment. .

Figure 5.11 provides the cumulative (unweighted) value of each evaluation category for each exercise of OC3. Figure 5.12 provides the cumulative (unweighted) value of each evaluation category for each evaluation conducted after the operational capability. Figure 5.13 displays the values of each measure—XMOTi, XCSTi, C2/FE—throughout each exercise of the final operational capability. Figure 5.14 displays the values of each measure—XMOTi, XCSTi, C2/FE—for each evaluation conducted after OC3.

F. SUMMARY

This final section frankly discusses the procedures, training, communications, hardware, and software as they relate to the V Corps DCP experiment throughout OC3. In addition, the conclusions of the TCATA evaluation, from Wintex 85, will be included where appropriate.

1. Procedures

Command emphasis of the V Corps C2 system was a reliable predictor of the satisfactory performance of, or delay in effective performance by, staff users during tests and exercises [Ref. 11:pp. 21-22]. Generally, if the commander emphasizes the experimental C2 system concept, user personnel respond accordingly [Ref. 8:p. 65-66].

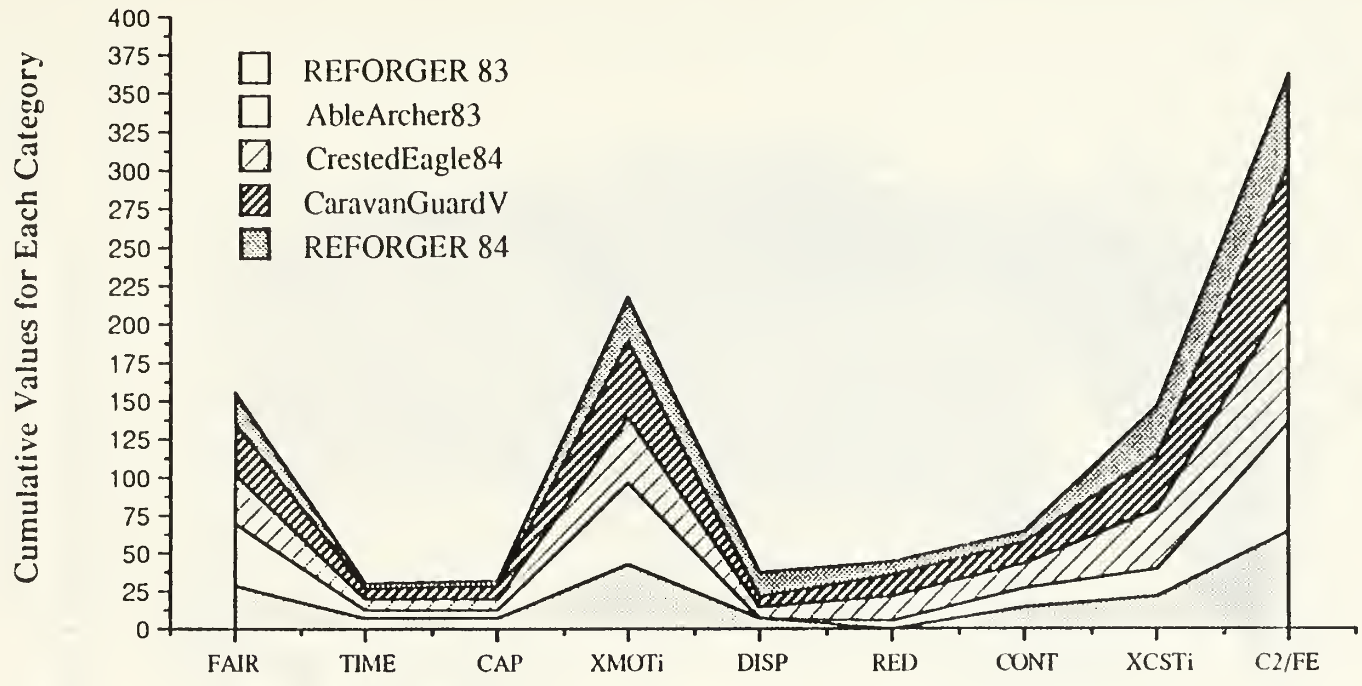

Figure 5.11. Evaluations of the Three Problems for OC3

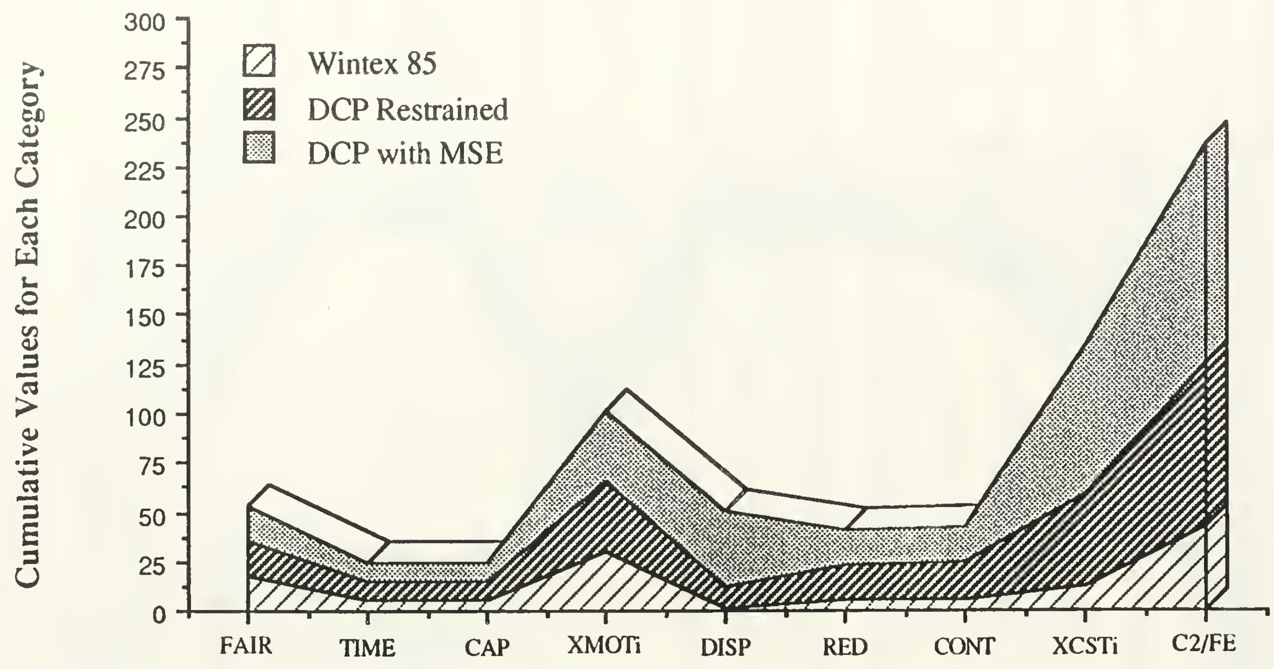

Figure 5.12. Evaluations of the Three Scenarios Beyond OC3

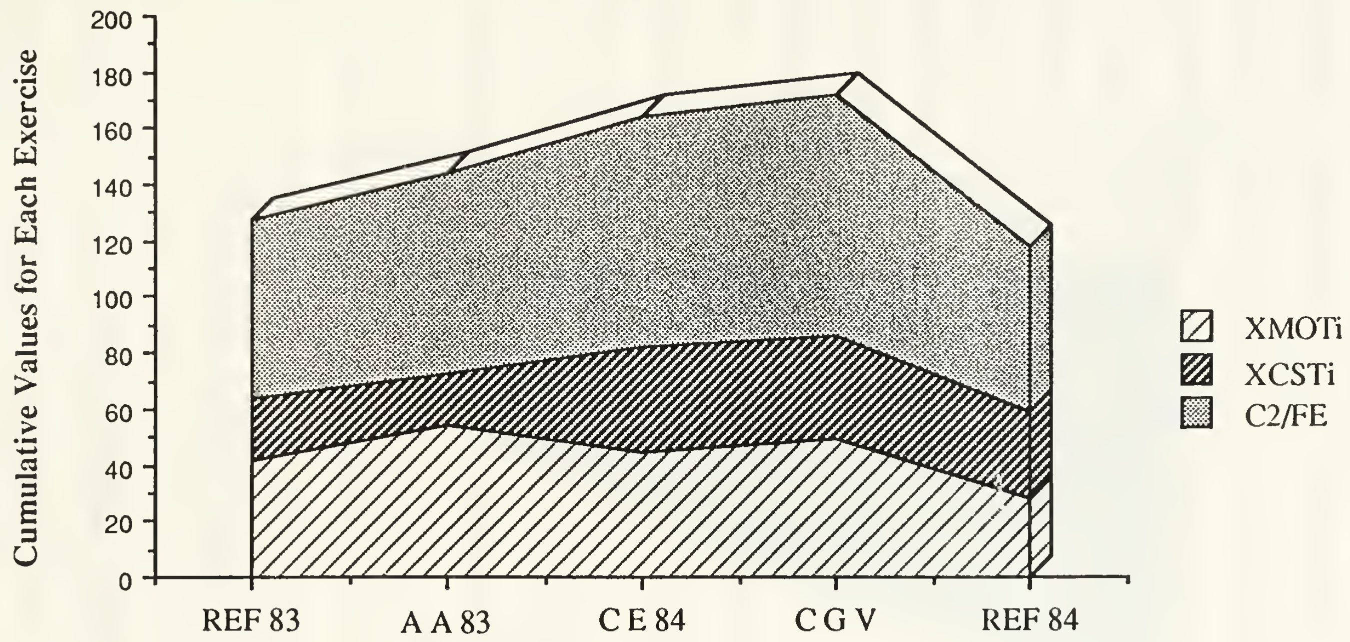

Figure 5.13. Comparisons of the Three Measures for OC3

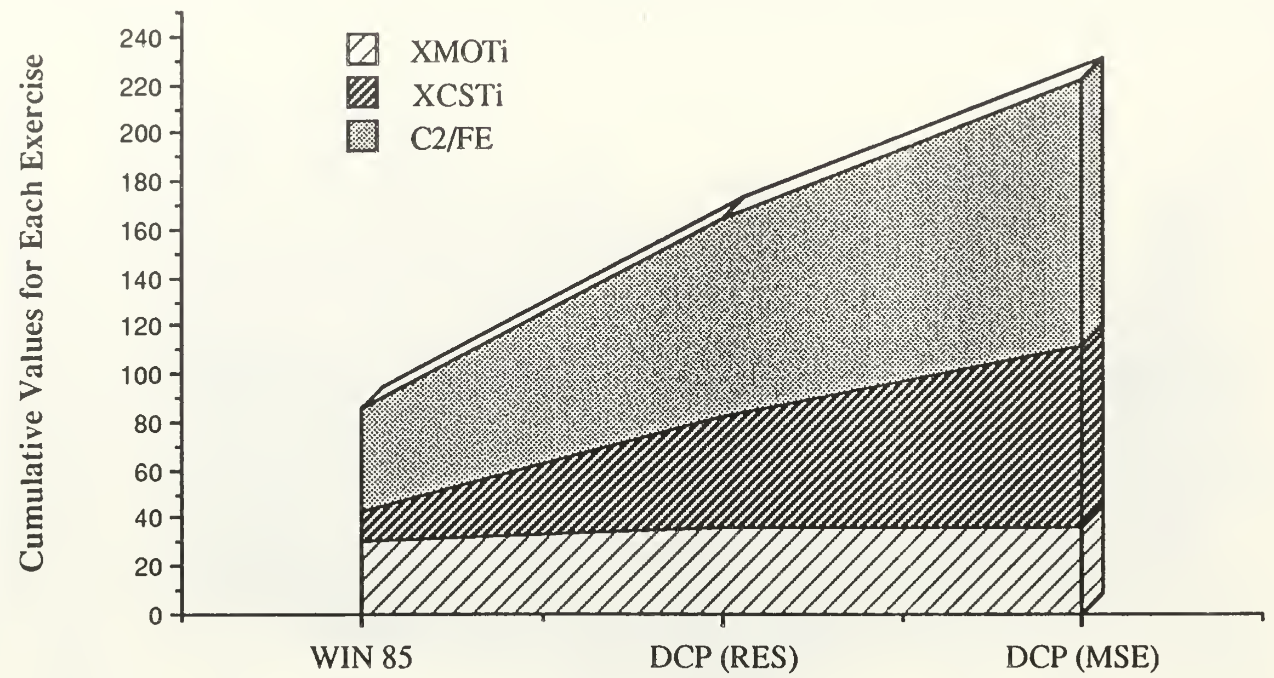

Figure 5.14. Comparisons of the Three Measures Across Three Scenarios

It was absolutely essential that thoughtful planning and procedures were documented. V Corps needed to document its objectives and operational procedures by constructing well-defined standing operating procedures (SOP). These SOPs should have reflected the evolutionary development of the V Corps DCP as it changed with new operating procedures, new goals and objectives, and system enhancements that followed hardware and software upgrades. The SOPs should have provided the following information for new personnel:

1. Operating procedures
2. Schematics and loading plans
3. Hardware operation and maintenance
4. Training procedures
5. Documentation requirements

Additions to the SOP needed to be systematically and faithfully updated if they were to serve their useful purposes as C2 mechanisms. Once again, this activity requires command emphasis and staff interest. [Ref. 8:pp. 65-66]

Lack of identification of information needed for the development of well-constructed SOPs was a crucial failure during the DCP program development. Such a commitment was necessary to ensure that personnel knew their duties; that the C2 system was maintained, set up, and operated properly; and that the organizations were in a position to identify new needs and applications for system evolution. There should have been a principal SPADS staff officer who had the backing of the commander and staff from the beginning of the DCP experiment. This individual should have been involved in the initial SOP development to provide the direction that guided systems integration throughout the staff elements and group functions. This principal staff officer should have assessed the manner in which system capabilities would assist in the performance of the staffs C2 functions.

Following exercises and tests, the usefulness of the system, its operability, and the identification of new capabilities should have been evaluated and incorporated into the SOP. Likewise, the failure to involve appropriate personnel in identifying communication, hardware, and software as well as training requirements created problems until the creation of the C2IO. [Ref. 8:pp. 66, 69]

2. Training

Sufficient operators and system managers were seldom available for all modules, particularly during field exercises when 24-hour operations exacerbated the requirement for continuous operations. Operators required hands-on practice on equipment between exercises; unfortunately, only the C2IO had the resources to maintain an entire, functional module during garrison operations. Well-trained SPADS operators and staff officers would have provided the maximum value to the V Corps C2 process if their duties had been integrated with SPADS capabilities.

The importance of training throughout the DCP experiment was profound. Those few personnel who were previously trained and/or had prior field experience gained the confidence and the skill necessary to experiment with applications which substantially improved the battlefield view available to the commander and staff. A systematic training program was necessary to provide sufficient numbers of properly-trained operators and system managers for 24-hour operations in all modules of the V Corps DCP. [Ref. 8:pp. 69-70]

3. Communications

The communication of accurate and timely battlefield information should have been the core of an effective, distributed C2 system whose twofold objectives consisted of sustained decision support and rapid information exchange capabilities throughout all DCP operations [Ref. 8:p. 71]. The fact that the C2IO was composed primarily of

communicators was met with some derision in January 1984. However, until operationally oriented communicators experienced SPADS from the inside, the C-E staff and Signal Brigade did not provide the consistent multichannel support required to make SPADS work at different locations and echelons. The C2IO's experienced communications planners were needed to make provisions for the staff to distribute information horizontally throughout the dispersed corps CPs and vertically from CENTAG down to the maneuver commanders. [Ref. 8:p. 75]

4. Hardware

As previously indicated, definition of requirements and identification of operational specifications were important considerations lacking in the SPADS system design. The lack of operational user involvement in the design of power systems, grounding protection, and the local area network caused critical failures during the 8ID SPADS program. Equally important, if not more critical, was hardware selection, modification, integration, and planned future innovations based upon testing and field exercise findings. There was a need for a concerted effort between the designer/engineer team and military users to ensure that hardware met military specifications in the field environment. Throughout the DCP experiment, the critical hardware components were packaged in rugged containers that nearly always protected them no matter what level of abuse they experienced; however, those "nice-to-have" items, e.g., graphics tablets and joysticks, were not made for, were not protected against, and could not withstand the users' operational environments. [Ref. 8:pp. 81-82]

This thesis has presented hardware issues that should be addressed when implementing and fielding an automated C2 system —based upon NDI acquisitions—in a DCP environment. The problems concerning power, grounding, interoperability, and usability could have been solved sooner if the operational users had been involved in the

design process from the beginning. Certain hardware problems may appear simple enough to avoid, suggesting that they need not have been mentioned. The experience gained from evaluating the SPADS system, however, indicates otherwise. The most fundamental mistakes occurred due to the human errors that resulted from basic design oversights. These numerous mistakes impeded the successful fielding and attainment of exercise objectives. SOPs and specifications, revision of documentation as technology and requirements changed, involvement of the operational user in the system design phase, and adequate time for preparation and planning are necessary for effective hardware integration. [Ref. 8:p. 76]

5. Software

Of all the C2 system components, the SPADS system software provides the best example of an element that must be tested by the operational user in evolutionary development cycles. Testing was essential if the software was to meet operational requirements, adequately automate staff procedures and functions, integrate successfully with existing hardware and with future upgrades, and respond to user requirements through hands-on, garrison-to-field operations. More than any other system component, the software evolved best after it was refined through exercise and field test. Conversely, software requirements, SOP documentation, and the identification of data structures were more difficult for the operational user to construct alone. Here the developer performed a poor service for the military user; instead of engaging in an intensive user-developer dialogue to get needed information, the developer simply selected and implemented his own doctrinal concepts. The rationale for having a software developer on-site—to furnish additional software support prior, during, and following exercises—was a sham; the local developer's representative was not allowed to make the required modifications on-site. Such changes were only authorized at the parent organization. [Ref. 8:p. 84]

6. TCATA Evaluation

The final section of this chapter regards the TCATA evaluation of SPADS during Wintex 85 [Ref. 22]. This evaluation was particularly appropriate to this thesis because it offered an outsider's perspective of what was happening in the V Corps DCP. The focus of that evaluation was germane to this research because it provided reinforcing and complementary data collected immediately after the third operational capability concluded.

The TCATA evaluation measured two general areas to determine whether the V Corps C2 system assisted the commander and staff: (1) did the overall V Corps C2 system assist the commander and staff; and (2) what assistance was provided by SPADS to the V Corps C2 functions, and what were the key characteristics [Ref. 22:pp. 11-49]? Each of these questions were addressed by sub-issues discussed below.

The two sub-issues to the first question were: (1) does the C2 system permit the commander and staff to monitor and be knowledgeable of the current tactical situation, and (2) are the V Corps communications adequate to support the C system? [Ref. 22:pp 11-37].

TCATA found that the V Corps staff "...consistently demonstrated the inability to monitor the overall tactical situation..." at all six modules. It also found that "...the staff, in general, was able to monitor the location data better when using SPADS." [Ref. 22:pp. 11-13] Further, it stated that equipment and personnel shortages in the V Corps Signal Brigade degraded its ability to perform its wartime mission [Ref. 22:pp. 13-21].

The TCATA evaluation presented the following recommendations that are directly related to the subject of this thesis [Ref. 22:p. 37]:

> Develop a standing operating procedure (SOP) that clearly establishes procedures for information flow (including SPADS) both within and between modules and echelons.
>
> Conduct section oriented staff training on staff procedures within the CP....

> Expedite fielding of mobile subscriber equipment; current C2 communications requires bulky equipment and is cable intensive....

The second area was divided into seven sub-issues, each of which are presented and discussed sequentially in the succeeding paragraphs [Ref 22:pp. 38-49]:

(1) What was the effect of SPADS on staff functions, organization, workload and procedures? TCATA's assessment was [Ref. 22:pp. 38-39]:

> ...There was a shortage of SPADS trained personnel.
>
> The corps staff needed additional training on staff procedures.
>
> SPADS was an asset since it improved C2 by providing the capability for word processing and hard-copy message traffic. But the system is difficult to learn and needs more efficient software.

(2) What were commander and staff perceptions of the system's products to support C2 functions? TCATA stated that the individual products were not rated separately from the system. This seems a glaring error on the part of the evaluation team. The sub-issue suggests that this should have been done; the evaluators spent 10 hours per day collecting data about such inconsequential matters as the number of times an operator logged onto the system. A rating scheme for the diverse information exchange and decision support capabilities would have permitted V Corps to invest its meager resources in the most valuable areas without expending resources of the entire system.

(3) What were the interoperability and interface capabilities of systems in support of the C2 system? There were no systems other than SPADS supporting the C2 system.

(4) What was the system's effect on operator workload and productivity? The TCATA assessment stated [Ref. 22:pp. 39-45]:

> Generally, the operators appeared to support SPADS and consider it an aid to getting their job done. However, it is felt that the system needs improvement, particularly in speed, reliability and simplicity of operation.

(5) How effective were the training and orientation programs in providing for the integration and the use of the system in the organization? TCATA correctly observed [Ref. 22:pp. 39-45]:

> The corps does have a multiechelon training program for SPADS. However, there appeared to be too little command emphasis on training which resulted in problems such as poor attendance and people starting a class without finishing it. There was a high personnel turnover which also reduced the level of proficiency of the average operator. In addition, the user manual is too complex for most operators.

(6) What is the in-garrison application of SPADS and how is training proficiency maintained? TCATA reported [Ref. 22:pp. 45-46]:

> The in-garrison applications of SPADS are minimal and consist mostly of infrequent use as a stand-alone device. Review training for system managers and operators is scheduled quarterly; however, the selection process for attendees is vague.

(7) What is the test availability of the C2 system? TCATA reported that the equipment was very dependable. They found that SPADS was available between 95 and 98 percent. [Ref. 22:pp. 46-48]

TCATA's overall assessment of the issue of whether or not SPADS provided assistance to the V Corps C2 system was that [Ref. 22:pp. 48-49]:

> The assistance provided by SPADS marginally improved the general capabilities of the commander and his staff to perform C2 functions during the CPX.

In the "Executive Summary" to the evaluation, TCATA summarized the following observations about SPADS and the V Corps DCP [Ref. 22:unnumbered 4th page]:

- SPADS was used to improve command and control by providing the capability for word processing and exchange of hard copy message traffic.
- SPADS was rated an asset by the staff.
- SPADS equipment was operational 95 percent of the time.
- There was very limited in-garrison use of the system.
- Of 27 operators, 19 stated they had received no formal training.

- There was a shortage of people in the plans and intelligence modules, and the plans and rear modules lacked the correct rank structure and skill levels.

- The system is difficult to learn and needs more efficient software.

- Erroneous data base entries occur because there are no mandatory or legal entries required for unit identification.

- The Battlefield Information Reporting System output cannot be used as received to readily determine the task organization and status of a unit.

- Due to data base contamination existing at the start of the exercise, SPADS did not provide a common perception of the battlefield.

7. Outlook

SPADS was an evolutionary development with each phase based upon the results of lessons learned during field exercises. In spite of the problems that naturally and inevitably occurred during a rapid fielding, SPADS' development clearly showed that the evolutionary development process was a viable method to rapidly field an effective C2 system. The benefits associated with this process were significantly quicker fielding and implementation, elimination of obsolescence, lower costs, end-user operation, and increased survivability.

The summaries of chapters III, IV and V presented a critical analysis of the state of procedures, training, communications, hardware, and software throughout the V Corps DCP experiment. Chapter VI will discuss recommendations and conclusions for SPADS, evolutionary development, and the Modular Command and Control Evaluation Structure.

VI. CONCLUSIONS AND RECOMMENDATIONS

Based on operational experience with SPADS at V Corps from 1984 through 1986, the author stated three problems, in Chapter I, that he would answer to evaluate the effectiveness of SPADS. The MCES provided the methodological framework to define, bound, and analyze SPADS and its evolving relationship with the V Corps DCP concept. Appropriate measures of performance, effectiveness, and force effectiveness were specified, through MCES, to answer these problems. The following sections are the author's own findings and opinions, except where otherwise noted.

A. SPADS PROGRAM CONCLUSIONS

SPADS evolved because of the following seven design mandates [Ref. 7:pp. 16-17]:

1. Provide an information exchange capability which would enable widely dispersed command post elements to maintain a common perception of the battlefield situation and thus effectively direct the employment of friendly forces
2. Provide automation of map displays for C2 support; minimize the time required to collect, process, analyze, store, retrieve, and display map information
3. Minimize data transmission requirements so the system can use available U.S. Army communications systems
4. Provide for survivability through a dispersed system that supports continuity of operations and rapid relocations
5. Provide computational support to each command post element
6. Develop a user-friendly system (one that is easily learned and understood, and easy to operate)
7. Provide a sufficiently rugged, low-cost system which will operate in a field environment and support field tests

These seven mandates were applied throughout each operational capability. Their influences were examined in Chapters III, IV, and V. These design principles can be

mapped to the SPADS statement of work tasks. They can be further mapped through OC requirements to specific implementations at the staff duty station, module and network levels. The following sections examine the application of each mandate, and discuss specific pros and cons of its implementation.

1. Maintain a Common Battlefield Perception.

Every module of the dispersed command post had to share a common perception of the battlefield situation if operations were to be effectively planned, executed, and controlled. This meant that every module had to share the same information. A key design concept of SPADS was the replication of the essential parts of the Current Situation information available at every module. In theory, designated staff sections in each module were responsible for maintaining a portion of the Current Situation data base and for transmitting updates to all other modules. This common perception design concept:

1. Allowed the commander and staff immediate access to critical data on the total situation at any module
2. Provided a common perception of all aspects of unit status to all headquarters modules
3. Provided the redundancy necessary for continuity of operations
4. Depended less on communications than remote query to a central data base
5. Relieved the staff from requesting information from distant modules, or from being queried by distant staff sections
6. Depended upon the following SPADS capabilities: DBMS (BIRS and OB), VBDS, Briefing, and—ultimately—Current Situation

a. Pros:

The Current Situation software worked. It was graphics-oriented and could clearly exhibit "exception data" at all modules. This was one of the first successfully completed software sub-modules of SPADS.

The Data Base Management System (DBMS) evolved into a powerful reports generator that delivered force structure information to all staff users. DBMS was consistent, accurate and timely. Its interface with the Video Battlefield Display System (VBDS) had the same characteristics. Both the DBMS and VBDS were able to provide the commander and the staff with a timely and accurate, common perception of the battlefield at any module.

b. Cons:

The entire Current Situation process was manual. Procedures were lengthy, complicated, and tiresome. The system was unpredictable to novice users and did not tolerate mistakes. Only an educated staff officer who had used the Current Situation data base software before could successfully enter the correct data in a timely manner. In fact, the entire process was so complicated that a contractor representative was usually required to enter the staff section's work. By 1985, Current Situation had devolved into an "undocumented" feature of SPADS.

The DBMS evolved under duress. As a file management system originally developed by the contractor merely to satisfy the SOW, the program did not begin to meet the needs of the commander and staff. By 1984, the Battlefield Information Reporting System (BIRS) portion of the DBMS had progressed to the point where it could meet most needs of the G3 Operations and Plans sections. However, BIRS still did not meet the needs of most other staff sections. Furthermore, the Order of Battle (OB) data base was static after initial development, and frequently was not used by any staff other than the G2.

2. Automate Map Graphics.

A key SPADS objective was to minimize the "culture shock" associated with the introduction of new equipment and procedures. The videodisc technology employed in SPADS stored over 50,000 color photographs of standard military maps from the Western

European theater. Map images were overlayed with standard military symbols and displayed on an analog color monitor. This method avoided computer-generated maps that didn't have a one-to-one correspondence with the standard tactical maps in the command posts.

a. Pros:

Everyone used the same maps, but could view them at the scale most appropriate to his/her tasks. Various combinations of friendly and enemy units could be displayed. All current force information in the data bases could be displayed simultaneously or be selected by echelons. Simple keyboard commands, help menus and easy operation made the VBDS one of the few software functions that could be mastered by any soldier.

b. Cons:

Although unit location information could be reliably displayed in a timely manner, no other standard military markings could be displayed easily. Various experiments with paddles, joysticks, and graphic tablets failed to provide a simple capability to draw appropriate force information on the screen and/or share that information with distant modules. VBDS software capability to "draw" this information using keyboard commands existed, but was quite difficult to learn and mastered by only a few "visually oriented" soldiers.

3. Minimize Data Transmission.

Limited communications capabilities in the corps area required a conservative data update philosophy to reduce the heavy burden imposed by graphic display data. SPADS' strategy was to transmit only overlay data by electrical means; backgrounds such as maps or chart matrices were to be pre-positioned at all locations or delivered by courier on floppy disk. Only the Briefing and Current Situation overlays that changed data were

sent through the communications network. This feature could reduce—by 1,000 percent—the communications load over what would have been required if complete graphics had to be transmitted throughout the network.

a. Pros:

The transmission of "exception data" certainly reduced the communications load imposed by employing a graphics-oriented decision support system. DAGMaR, a successful solution that incorporated links between the decision graphics, data base, and spreadsheet. In fact, DAGMaR was able to transmit only the changed values from the spreadsheet to produce updated graphics for all recipients.

b. Cons:

The original graphics programs—commercial products incorporated into SPADS—were too cumbersome to use, so few, if any, backgrounds were completed before they were needed. Bi-daily courier runs were not timely enough to carry critical graphics needed for Current Situation software. The staff users were thus forced to transmit entire graphics throughout the system and thereby reduced the capacity of the network by a factor of ten. This seriously strained the capacity of the early gateways, and imposed a severe load on the tactical communications system.

4. Maintain Continuity of Operations.

This critical requirement influenced both SPADS equipment configuration and recommended employment concept. The basic philosophy was to design for graceful degradation. If part of a staff duty station, or part of an entire module should fail, the remaining components would continue to operate. Specific design features incorporated were as follows:

1. Distributed intelligent staff duty stations were selected rather than traditional, less capable work stations serviced by a multi-user central computer. If a staff duty station failed, the highest priority tasks could be completed on remaining stations. Each staff user had dedicated equipment so that he/she did not compete for processing resources during crisis periods.

2. A medium-speed printer provided hard copy messages and ensured essential record traffic was maintained in the event of a major system failure.

3. A direct access communications (DAC) interface to and from selected high priority staff duty stations provided timely communications. DAC accomplished this despite substantial traffic backlogs and provided manual interfaces to other microcomputer-based systems, such as TAP.

4. The data bases, Current Situation briefings, and map videodiscs were duplicated at each module. Enough data existed at each module to replicate the functions of any other module should one be destroyed or otherwise lost from the network.

a. Pros:

Since all staff duty stations were intelligent microcomputers, staff sections could use commercial software to compensate for capabilities not provided by SPADS software. Each module's shared output station (SOS)—the medium-speed printer—was critical for printing and distributing OPLANS and OPORDS or lengthy data base reports. In addition, all FLASH message traffic for each user was automatically printed at the SOS. The DAC provided the ability to "network" non-connected equipment suites such as SPADS and TAP. Replication of hardware and software at each module was reinforced by corps SOPs and staff organization that placed complimentary personnel at each module to maintain continuity of operations.

b. Cons:

Although the staff duty stations were state-of-the-art in 1981, they were not upgraded throughout the lifetime of SPADS. Compared to later, more capable microcomputers, the system's components were merely able to hold established ground as demands on the system increased. The DAC was actually a work-around for the real solution, which would have been to net SPADS and TAP; unfortunately this was not a

funding priority, so information had to be extracted from either system and then typed in again by the operator.

5. Provide Computational Support.

Each staff section in a module might have its own set of requirements for analysis, such as generating spreadsheets or personnel and equipment status reports, or for creating local data bases. SPADS was designed to provide the capability to execute non-SPADS programs and to create local programs to meet the needs of each staff section. This capability ensured maximum utilization of existing programs and enabled staff sections to develop software tailored to their unique needs.

a. Pros:

Initially SPADS had no number-crunching capabilities, so various staff sections took advantage of the commercial program Visicalc[1] to meet their needs. Certain functional algorithm software had been developed by the Command and Control Microcomputer Users Group (C2MUG), headquartered at Fort Leavenworth, KS, that could be executed on the staff duty stations. Programs for weather, NBC, force projection, and logistics were frequently used.

b. Cons:

Users were continually frustrated in their efforts to share the results of their local applications with distant users since SPADS did not support any transmission standards but its own. When SPADS finally got a spreadsheet, users welcomed it until they found it was vastly inferior to the software they had given up. Furthermore, "home-grown" programs written to run on the SPADS operating system quite often crashed the

---

[1]Visacalc is a registered trademark of Software Arts, Cambridge, Massachusetts.

entire local area network if they had any failures, and sometimes could even create havoc inside of the operating system itself.

6. Develop a User-Friendly System

Using familiar formats and simple equipment would ensure effective operation in the stress of field use. Ideally, the SPADS design principles would consistently involve the following concepts:

1. The SPADS program provided prompts to the operator on steps necessary to perform each function

2. The automated map display used images of standard Army maps stored on videodisc to present a display identical to the working maps used in the tactical command posts

3. The graphics backgrounds and message formats were designed to look similar to the paper message formats currently in use; users adapted SPADS to conventional formats whenever desired

a. Pros:

Several programs were powerful, flexible and concise; they had good visual prompts and useful help menus. The VBDS images were identical to the standard tactical maps on the walls of the command posts.

b. Cons:

Most programs running under the SPADS main command line were "user-hostile"; they provided incomplete on-screen clues that were meaningful only to the programmers, many had no help screens at all, and a few allowed no mistakes in, or escapes from, tedious sequences of input and keypresses. Quite often undocumented features from previous versions of programs were left on the system for the unwary user to stumble onto with unpredictable results.

The ideal of common backgrounds was almost never achieved due to the severe difficulty in manipulating the graphics programs to look like standard formats. Most

staff officers either put up with what was already on the screen or merely employed blank backgrounds rather than fighting with the system.

7. Provide a Rugged, Low-cost System

SPADS used commercial microcomputer equipment modified for field use, the time to develop and field SPADS was about one-fifth of a normal development cycle because of the use of off-the-shelf commercial products. This also maintained low costs. Obviously, it was necessary to take some steps, without attempting full militarization, to ensure that the system would perform well in the field. First, the microcomputers were modified by the addition of a backplane that provided simple connections between the computer and other devices in the system. This circumvented the need to open the microcomputer case and expose sensitive parts in order to make connections. Second, special transport cases were designed to protect the equipment during transportation and provide the physical support for each work station.

a. Pros:

The use of nondevelopmental item (NDI) equipment certainly accelerated the arrival of SPADS to the operational user. Existing operating systems and programming languages for these microcomputers further accelerated program development. Use of backplanes made it easier for the SPADS operator to learn to install, operate and maintain the equipment. The special transport cases were extremely rugged and sufficiently protected all of the equipment from severe abuse during transportation and field employment.

b. Cons:

The microcomputers selected were the most powerful available during the system start. Unfortunately as newer, more powerful, and less expensive microcomputers rapidly became available, SPADS was stuck with its original staff duty stations, and no amount of modifications later on could increase either capacity or processing power. The

backplanes were a quick idea that wasn't thought through; the connections, while simple, were much too fragile for field tests, and equipment was frequently out of commission because it couldn't be connected to the LAN. The transport cases were extremely effective, but their handles and closures seemed to have been added as design afterthoughts.

B. SPADS PROGRAM RECOMMENDATIONS

Reviewing the history of SPADS' evolutionary development program, certain lessons can be derived for planning, training, communications support, and procedures. These lessons are applicable to any new C2 system, but are especially important to a program that evolves over time based upon the lessons learned by its operational users.

First, SPADS needed the V Corps commander's emphasis—from the time the original request for assistance was sent to DNA through the end of OC3. In 1982, McGrew and Jutte observed the fledgling SPADS experiment during Caravan Guard III; at that time they noted the critical necessity of getting the commander and staff behind the project to ensure its success [Ref. 12:pp. 21-22]. As new commanders took control of the corps, their interests in SPADS changed with what they perceived it could do for them at any given time. Unfortunately SPADS could not be an effective command and control tool unless the commander insisted on its use for his critical decision making information. This was not consistently the case until the spring of 1984, after C2IO had been created to manage the V Corps C2 system.

After the commander's expressed interest, the next major problem was training personnel to use SPADS in accordance with established command post procedures. Once again, there was not real progress in this area until the C2IO had been established. Prior to that time, the major lessons learned relating to training were:

1. Every module needed dedicated SPADS operators
2. Operators required formal training

3. NCOs and staff officers needed training which emphasized the interpretation of outputs as well as SPADS operating procedures

4. Operator proficiency could only be maintained in garrison by using the system capabilities to perform peacetime functions

5. A regular training plan that included periodic refresher training was required

6. Trainees had to be able to attend SPADS training without interruptions

7. A "field-proof" quick reference guide was needed to supplement the User's Manual

A corollary of the training problem was a total lack of established, SPADS-based command post procedures. The DCP program started at V Corps in 1981; until the V Corps DCP LOI was distributed in the spring of 1985, the only SOP written for SPADS involved Current Situation. Three recommendations that would have greatly increased the effective use of SPADS throughout the OCs are:

1. Develop written procedures for the use of SPADS and for internal processing of SPADS information

2. Require and enforce scheduled updates of all reports required through SPADS

3. Ensure that the system is ready before field use; clean out the data bases and fill Current Situation with briefings

In the realm of technology and communications, V Corps had a critical need for on-site expertise to guide the system from initial fielding through full operation. The expertise was available—in the Communications-Electronics staff and the Signal Brigade—but those experts were not tasked by the commander to participate in this project. They could have assisted operational users in defining the critical information needs of the commander and staff. They certainly could have ensured the selection of the four-wire autodial modems needed from the beginning of the DCP experiments that were never fielded. Finally, they could have planned the field use and development of SPADS so that communication requirements complemented the scarce signal resources of the corps, rather than exacerbated them.

C. EVOLUTIONARY DEVELOPMENT CONCLUSIONS

Throughout the 1980s, Army C3 systems were being proposed to satisfy operational users' needs from division through theater levels. The principal system in the Army Command and Control Master Plan during the past decade has been the Maneuver Control System (MCS). MCS is a product of the traditional concept-based requirements definition process. MCS is envisioned as a fully militarized, general purpose, data processing, display and communications system designed to be the backbone of Army tactical C2 [Ref. 25:pp. 56-57]. Although originally scheduled for fielding in the mid-1980s, mounting costs and program slippages have (almost) annually put the system in jeopardy before Congress.

The evolutionary development approach used throughout the SPADS program met the immediate command and control requirements of military users while maintaining flexibility to respond to changing requirements and advancing technology. The use of carefully selected and configured off-the-shelf commercial products put the components of the first operational capability in the field in months instead of years. Starting in September 1981, V Corps operational users were immediately able to test system capabilities as well as C2 procedures during each field test and exercise.

System enhancements and corrections were made within each operational capability cycle by adding or replacing hardware components and by integrating new software tailored to meet specific military requirements. Subsequent OC cycles consolidated incremental enhancements or involved system upgrades which took advantage of major advances in microcomputer technology. [Ref. 26:pp. 60-63]

Three of SPADS' key achievements within V Corps were: (1) helping define commander and staff C2 requirements, (2) providing a basis for conceptual and doctrinal development, and (3) putting a C2 capability into the field in the near term. In August

1984, the TRADOC Deputy Chief of Staff for Combat Developments wrote [Ref. 25:pp. 55-56]:

> One of the programs the Army is evaluating is called the Staff Planning and Decision Support System (SPADS)....The experience the Army is gaining in SPADS and...related programs is directly guiding the evolution of our Maneuver Control System (MCS).

D. MCES APPLICATION CONCLUSIONS

Other NPS degree students who employed MCES were able to draw from either an established body of work or a team of experts when evaluating their chosen C2 systems. Since SPADS was a unique exploratory program, this researcher had no such traditional sources for guidance or assistance. In addition, SPADS had already completed its evolutionary life cycle from concept through three operational capability stages to fully deployed system. During that term there had been two highly unfavorable evaluations by the U.S. Army TCATA; in fact, one deputy director, Mr. Reedie A. Stone, Jr., stated: "With respect to SPADS, it didn't work and I recommend that the corps contact the GSA for disposal instructions[1]." In direct contrast to this, the DNA Program Manager for SPADS, LTC Robert E. Laird, stated: "DNA considered SPADS as success as a proof of concept."[1] It was obvious at the outset that an objective evaluation of SPADS using the MCES would present some challenges.

The Modular Command and Control Evaluation Structure proved itself to be a robust and powerful framework for evaluating the Staff Planning and Decision Support system. It was flexible enough to evaluate the three problem areas presented in Chapter I

---

[1]Letter addressed to author by Mr. R. Stone, Deputy Director, BATD, TEXCOM, Subject: Request for Information on the Staff Planning and Decision Support System, dated 14 December 1987.

[2] Phone conversation with LTC Laird, 23 November 1987.

under four different evolutionary conditions. The evaluations proceeded iteratively from the V Corps baseline through the three operational capabilities.

Throughout Chapters III, IV, and V this thesis specifically assessed SPADS' effectiveness for the following three problems:

1. Did SPADS provide the V Corps commander and his staff with the ability to exercise command and control of combat assets to meet overall mission objectives?

2. Did SPADS demonstrate that the dispersed command post concept enhanced command survivability?

3. Did SPADS evolve as a command and control force effectiveness system for the V Corps DCP based upon operational lessons learned?

The resolution of the first problem required a measure of effectiveness that was derived from the three part definition of a C3 system. This problem addressed C2 mission orientation in terms of the C2 process, structural components, and physical entities for the evolving interaction between SPADS and the V Corps Dispersed Command Post concept. The Summaries of Chapters III, IV, and V individually addressed the changing aspects of this problem. Figure 6.1 provides graphic evidence that SPADS provided the commander and his staff increasing value for C2 mission orientation, XMOTi, throughout the three year experiment.

The second problem addressed command survivability, in terms of the facilities, equipment, procedures, personnel and information flow patterns that made up the V Corps Dispersed Command Post. Until the V Corps commander and staff provided effective leadership and management of SPADS during OC3, command survivability increased only slightly in value. After the C2IO was established, the staff sections and elements of each command post received the expertise required to consistently increase command survivability. The center section of Figure 6.1, XCSTi, clearly shows that SPADS, together with the DCP, enhanced survivability during the last operational capability cycle. The third problem measured—across levels of operational capacity—the evolution of C2

force effectiveness together with survivability. This final measure of command and control evolution was derived as a function of the MOFE from Problem 1 and the MOE from Problem 2, with respect to time. The C2/FE layer in Figure 6.1 graphically reinforces the conclusions reached in Chapters III, IV, and V. As SPADS evolved from August 1981 to March 1985, it provided distinct advantages to V Corps in terms of C2 force effectiveness, C2 mission orientation, and command survivability.

E. MCES RECOMMENDATIONS

1. Further Testing and Refinement

MCES is a powerful evaluation framework; like any such system or methodology, it has a steep learning curve. The only way to learn to use MCES is by applying the seven iterative modules. Any analyst interested in employing MCES would be well-advised to both examine the written results of previous evaluations and to begin applying the methodology as soon as possible—ideally with guidance from an analyst that has applied MCES in a similar problem area.

The present literature on MCES presents a diverse approach to this evolving methodology. One refinement to MCES that would allow analysts and decision makers to communicate more effectively throughout the MCES evaluation process would be a glossary or "thesaurus" of MCES terminology and concepts. Another valuable effort would be the pooling of previous MCES evaluations into a knowledge base that could be used to develop a microcomputer-based toolset for the MCES analysts.

2. Education and Dissemination

The MCES is a systems approach to the evaluation of C2 systems. It is a valuable framework for any planner, engineer, or analyst who is charged with evaluating C2 systems at any stage of development in the defense acquisition process.

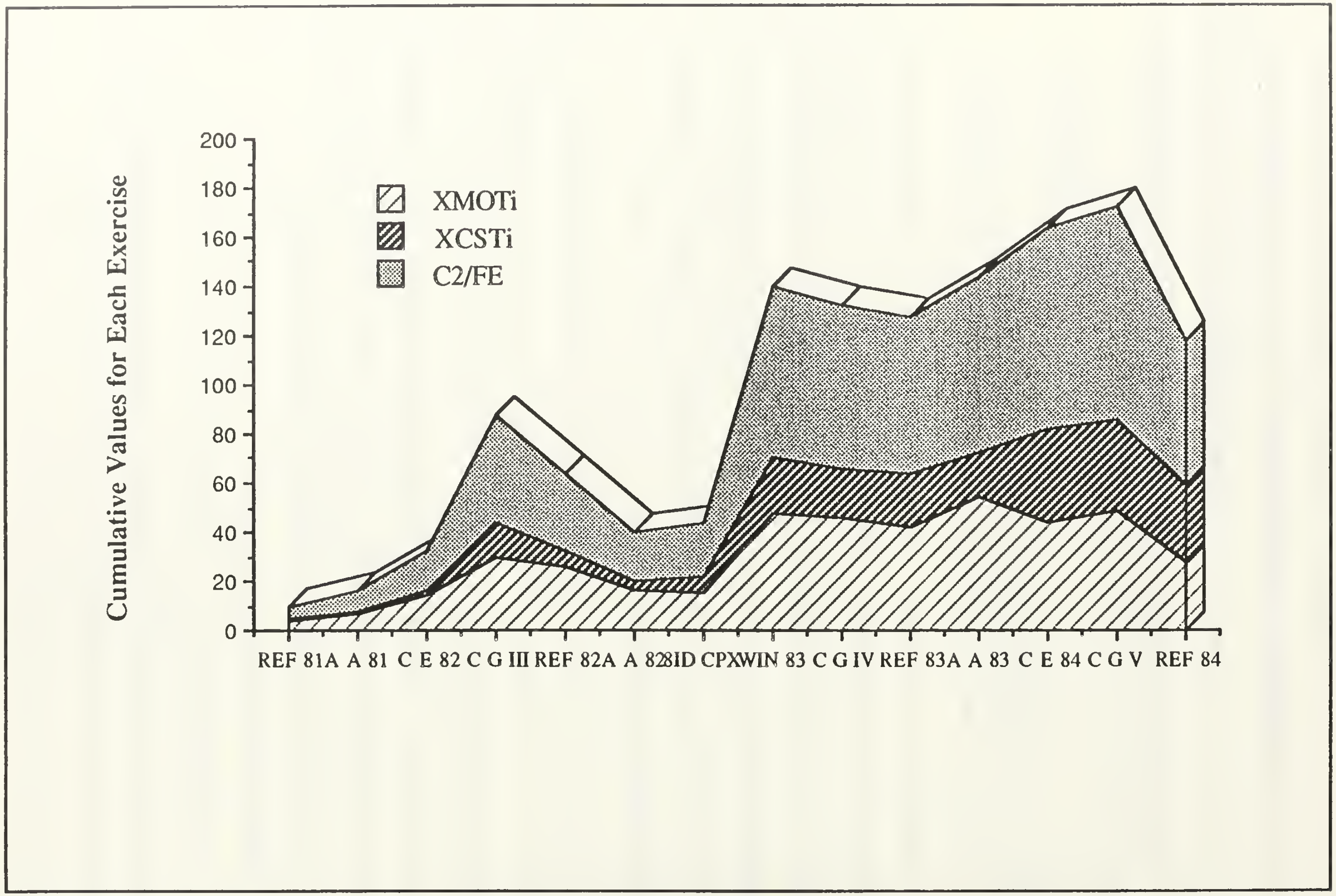

Figure 6.1. Comparison of the Three Measures Across All Exercises

The Modular Command and Control Evaluation Structure is a flexible framework that would add great value to an appropriate course in the C3 curriculum at the Naval Postgraduate School. The experience gained from applying MCES in a controlled academic setting would assist C3 graduates in future assignments. MCES can assist the military officer in: identifying C3 system requirements; applying operational experience and technical knowledge to evaluate the effectiveness of C2 systems; evaluating R&D projects as well as technical and engineering studies; integrating the results for near- and long-term C3 system improvements; planning C3 aspects of operations, exercises, and tests; and developing joint C3 systems plans, operating concepts, and policy.

Future C3 graduates who have used MCES in their academic work at NPS will be better able to fulfill their responsibilities in the field of command, control, and communications. That experience will assist them in their efforts to analyze the technical and operational aspects of C3 environments as they effectively interface with engineers, planners, and operational personnel in the development of new C3 systems and the improvement of old systems.

APPENDIX A
GLOSSARY OF ACRONYMS AND ABBREVIATIONS

AC	Alternating current
ACofS	Assistant Chief of Staff
ACR	Armored cavalry regiment
ACTO	Army Communicative Technology Office/action officer
ADA	Air defense artillery
ADE	Air defense element
ADM	Atomic demolition munitions
AFSOUTH	Air Forces Southern Europe
ALO	Air Liaison Officer (Air Force)
ALT	Alternate
AMO	Automation management officer/office
APP	Appendix
ARI	Army Research Institute
ASIC	All Source Intelligence Center (Intelligence module)
ASOC	Air Support Operations Center (Air Force)
ATC	Air traffic control
ATK	Attack
AVN	Aviation
AUTODIN	Automatic Digital Network
AUTOSEVCOM	Automatic Secure Voice Communications
AUTOVON	Automatic Voice Network
AVAIL	Available
B&G	Black and green (monochrome)
BCC	Battle Control Center (Air Force)
BIRS	Battlefield Information Reporting System (SPADS DBMS)
BIRSIN	BIRS input report
BPS	Bits per second
C^2	Command and control
C^2IO	Command and Control Initiatives Office (V Corps)

C^2MUG	Command and Control Microcomputer Users Group
C^3	Command, control and communications
C^3CM	Command, control and communications countermeasures
C^3I	Command, control, communications and intelligence
CACDA	Combined Arms Combat Development Activity
CATDA	Combined Arms Training Development Activity
CAM	Common area maintenance (SPADS function)
CAS	Close air support
CAME	Corps Airspace Management Element
CBC	Current battle cell
CBM	Current battle module
CCA	Command and Control Automation Office (V Corps)
CCIR	Commander's critical information requirements
CDR	Commander
CE	Communication-Electronics
CECOM	Communication-Electronics Command
CENTAG	Central Army Group (NATO)
CEOI	Communications electronics operating instructions
CFV	Combat fighting vehicle
CGS	Communications gateway station (SPADS hardware)
CLiP	Communications link processor (SPADS hardware)
CMB	Collection management branch (Intelligence module)
CMD	Command
CMO	Civil-military operations
COM	Center of mass
COMM	Communications
COMSEC	Communications security
CONUS	Continental United States
COSCOM	Corps support command
CP	Command post
CPU	Central processing unit
CPX	Command post exercise
CRC	Cyclical redundancy check
CRYPTO	Cryptographic

CSMA	Communications Security Maintenance Agency/ carrier sense multiple access
CSS	Combat service support
CTOC	Corps tactical operations center
CTOCSE	CTOC support element (Intelligence module)
DAC	Direct access communications (SPADS software)
DAGMaR	Data and graphics manufacture and retrieval (SPADS software)
DATEX	West German data network of the Deutsches Bundespost
DAViD	Data automated video display (SPADS II software)
DBMS	Database Management System
DBP	Deutsches Bundespost (West German telecommunications agency)
DCP	Dispersed command post
DCSOPS	Deputy Chief of Staff for Operations
DEMO	Demonstration
DISCOM	Division support command
DIV	Division
DIVARTY	Division artillery
DMD	Digital message device (TACFIRE hardware)
DNA	Defense Nuclear Agency
DOD	Department of Defense
DP	Dimensional parameters
DTAC	Division tactical command post
DTD	Dated
DTG	Date time group
DTMF	Dual tone multiple frequency
DTOC	Division tactical operations center
ECC	Exercise Control Center
ECCM	Electronic counter-countermeasures
ECM	Electronic countermeasures
ECP	External communication processor (SPADS hardware)
EDP	Exploratory Development Program

EMP	Electronic mail processor (SPADS hardware)/ electromagnetic pulse
EMS	Electronic Mail System (SPADS software)
ENGR	Engineer
EPW	Enemy prisoners of war
ESM	Electronic security measures
EST	Estimate
EVAL	Evaluation
EW	Electronic warfare
EXER	Exercise
FA	Field artillery
FAC	Forward air controller (Air Force)
FAIR	MOE for evaluating C2 Process (flexibility, availability, interoperability ,and responsiveness)
FC	Field Circular
FLOT	Forward Line of Own Troops
FLOTREP	FLOT report
FM	Field manual/frequency modulation
FORSCOM	Forces Command (Army)
FRAGO	Fragmentary order
FSCOORD	Fire support coordination officer
FSE	Fire support element
FSM	Fire support module
FTX	Field training exercise
FY	Fiscal year
G1	ACofS G1, Personnel and Administration
G2	ACofS G2, Intelligence
G3	ACofS G3, Operations
G4	ACofS G4, Logistics
G5	ACofS G5, Civil-Military Operations
GATEWAY	Communications gateway station (SPADS hardware)
GFE	Government furnished equipment
GMGR	Gateway Manager (SPADS software)
GSA	General Services Agency

HEL	Helicopter
HPITS	DAC software (SPADS)
HQ	Headquarters
HZ	Hertz (cycles per second)
ID	Identify/identification
IFFN	Identification, Friend, Foe or Neutral Joint Testbed
IFP	Interfile Processor (SPADS software)
IMP	Intermodule communications processor (SPADS hardware)
INCL	Inclosed/included
INFO	Information
INTEL	Intelligence
INTSUM	Intelligence summary
IOC	Initial operational capability
IR	Intelligence requirement
JAAT	Joint air attack team
JCS	Joint Chiefs of Staff
KBYTE	Kilobyte
KM	Kilometer
KT	Kilotons
LAN	Local area network
LANCE	Nuclear-capable field artillery system
LNO	Liaison officer/office
LOG	Logistics
LOI	Letter of Instruction
LTC	Lieutenant Colonel (Army)
LTCOL	Lieutenant Colonel (Air Force)
MAIN	Main command post
MBYTE	Megabyte
MBPS	Megabyte per second
MCES	Modular Command and Control Evaluation Structure
MCS	Maneuver Control System (Army C2 system)
METT-T	Mission, enemy, terrain, troops and time available
MICRO	Microcomputer/microprocessor

MICROFIX	Army intelligence workstation program
MLRS	Multiple Launch Rocket System
MM	Millimeter
MOE	Measure of effectiveness
MOFE	Measure of force effectiveness
MOP	Measure of performance
MORS	Military Operations Research Society
MP	Military Police
MSE	Mobile Subscriber Equipment
MSR	Major supply route
MSS	Mass storage station (SPADS hardware)
MUX	Multichannel communications
NBC	Nuclear, biological and chemical
NCO	Noncommissioned officer
NCP	Network control processor (SPADS hardware)
NCS	Network control station
NDI	Nondevelopmental item
NETT	New equipment training team
NLT	Not later than
NPS	Naval Postgraduate School
O/H	Quantity on-hand
OB	Order of Battle (SPADS DBMS)
OC	Operational capability
OE	Organizational effectiveness
OJT	On-the-job training
OMNINET	SPADS local area network
OPCON	Operational control
OPLAN	Operations plan
OPNS	Operations
OPORD	Operations order
OPS	Operations
OPSEC	Operations security
PDR	Power distribution and regulation
PIR	Priority intelligence requirement

PLU	Position location uncertainty
PMB	Production management branch (Intelligence module)
POCE	Proof of concept experiment
PP	Pages
PSYOP	Psychological operations
PTT	Post Telephone Telegraph
PUB	Publication
QTR	Quarter
R&D	Research and development
RAOC	Rear Area Operations Center
REF	Reference
REFORGER	Return of Forces to Germany (Annual exercise)
REQ	Required
S&FC	Store and Forward Concentrator (Gateway software)
SDI	Strategic Defense Initiative
SDS	Staff duty station (SPADS hardware)
SHAPE	Supreme Headquarters Allied Powers Europe
SIGSEC	Signal security
SITREP	Situation report
SOP	Standing operating procedure
SOS	Shared output station (SPADS hardware)
SOW	Statement of work
SPADS	Staff Planning and Decision Support System
SPADS II	UDDAS (USAREUR HQ's experimental C2 system)
SPOTREP	Spot report
SPT	Support
STARTEX	Start of exercise
SUPCOM	Support command
SWO	Staff weather officer/office (Air Force)
SYMTEC	Graphics overlay device (SPADS hardware)
TAC CP	Tactical command post
TACAIR	Tactical air support
TACFIRE	Army field artillery command and control system
TACIP	The Army Command and Control Initiative Program

TACP	Tactical air control party (Air Force)
TAP	Target Acquisition and Planning system
TASKORG	Task organization report
TASS	Tactical Army Switching System
TCATA	TRADOC Combined Arms Test Activity
TCT	Tactical Computer Terminal (MCS hardware)
TGT	Target/targeting
TIB	Target intelligence branch (Intelligence module)
TNF	Theater nuclear forces
TOC	Tactical operations center
TOPO	Topographic
TOW	Guided antitank missile
TRADOC	Training and Doctrine Command (US Army)
TTY	Teletypewriter
UCC	Umpire Control Center
UDDAS	USAREUR Distributed Decision Aids System (USAREUR HQ's experimental C2 system)
UPS	Uninterruptable power supply
USA	U.S. Army
USAF	U.S. Air Force
USAFE	U.S. Air Forces Europe
USAREUR	U.S. Army Europe
VBDS	Video battlefield display system (SPADS software)
VCR	Videocassette recorder
VDP	Videodisc package
VOL	Volume
WINTEX	Biannual winter exercise in Germany (Army)
WWMCCS	Worldwide Military Command and Control System
WX	Weather
XTEL	Crosstell process

APPENDIX B

SPADS STATEMENT OF WORK[1]

Task 1: V CORPS SUPPORT. Provide software support to V Corps during REFORGER 81, Able Archer 81, Crested Eagle 82:
(1) Plan, train, assist, and report
(2) Applications/data base development

Task 2: DCP CONCEPTS. Identify and test feasible information exchange concepts for DCP:
(1) Communications networking
(2) CONUS testing

Task 3: CARAVAN GUARD SUPPORT. Contractor shall support V Corps test of DCP:
(1) Plan, train, assist, report
(2) Develop SOP for dispersed operations using microcomputer equipment
(3) Communications gateway software development
(4) Deliverables

Task 4: PTT MANAGEMENT INTERFACES/PROCEDURES. Document and demonstrate how the DCP can utilize the Deutsche Bundespost (DBP):
(1) Document management procedures/interfaces
(2) DATEX test

Task 5: V CORPS/8 ID COMMAND AND CONTROL DOCTRINE EVALUATION:
(1) Develop a capability to evaluate, through evolutionary testing, the effectiveness of and requirements for emerging Army doctrine on dispersed field C2

(2) The principal effort will be to develop a testbed for providing an information distribution and processing system between the corps, division, and corps/division command elements

(3) The final test plan will provide a basis for documenting and evaluating the results of the theoretical efforts related to the internal corps and division C2 operations

---

[1]SOURCE: LTC Robert Laird, Defense Nuclear Agency, UNCLASSIFIED Letter to the author, Subject: SPADS, 23 November 1987.

Task 6: NUCLEAR AIR BATTLE MANAGEMENT (Conducted for USAFE)

Task 7: SUPPORT FOR REFORGER AND ABLE ARCHER:
- (1) Provide "on-site" contractor liaison support for V Corps
- (2) REFORGER 1982 support
- (3) Operational test of full-up DCP concept
- (4) Assist V Corps in developing SOPs required to operate effectively in each functional area.
- (5) Conduct a series of tests of the various modules separately to refine SOPs
- (6) Applications software enhancements [From Task 3]
- (7) Deliverable

Task 8: 8TH INFANTRY DIVISION AIRLAND BATTLE COMMAND POST PROGRAM:
- Sub-task 8a: Procure, develop, test, and deliver the division SPADS system
- Sub-task 8b: Conduct user training
- Sub-task 8c: Support user test of system in garrison
- Sub-task 8d: Support user tests of system in field environment
- Sub-task 8e: Support tests of SPADS during REFORGER 82

Task 9: BASELINE SUPPORT (REFORGER 82, Able Archer 82, WINTEX 83, Caravan Guard 83):
- (1) Increase the overall effectiveness of the system
- (2) Increase the user friendliness
- (3) Improve clarity

Task 10: ON-SITE SUPPORT THROUGH WINTEX 83

Task 11: 16-BIT MICROPROCESSOR COMMUNICATIONS GATEWAY:
- Sub-task 11a: Gateway software conversion

Task 12: SPADS SYSTEM TRAINING DOCUMENTATION:

Sub-task 12a: Written instructional materials:
- (1) Users' guide to the software
- (2) Technical user notes
- (3) Concept of operations

Sub-task 12b: Audiovisual training

Task 13: DCP VIDEO DISC SUPPORT

Task 14: PROVIDE SUPPORT TO EXERCISE CARAVAN GUARD IV:
- (1) Pre-exercise training
- (2) Equipment upgrades
  - (a) ACTO SDS for CBC and Intel modules
  - (b) Upgrade CGS
- (3) Exercise support

Task 15: PROVIDE EXTENDED EXERCISE SUPPORT. Test objectives and key data elements needed for evaluation of the exercises will be identified for each CPX, FTX, etc., so that Army systems evaluators can monitor program progress

Task 16: PROVIDE CONTINUED SOFTWARE AND HARDWARE SUPPORT FOR THE DCP PROGRAM:
- (1) Refine/correct software problems identified in previous tasks
- (2) Continue 16-bit microprocessor CGS software development
- (3) Provide technical and hardware support to AFSOUTH and SHAPE Technical Center in their DCP activities

Task 17: SOFTWARE SUPPORT (through 2nd Qtr FY 84):
- (1) Continue development of 16-bit communications gateway
- (2) Continue user identification requirements
- (3) Customize software for division usage

Task 19: ON-SITE SUPPORT FOR DCP PROGRAM:
- (1) On-site support personnel (2)
- (2) Establish an on-site coordination office at V Corps HQ
- (3) On-site support

Task 20: CONTINUED SUPPORT:
- (1) Provide exercise software support
- (2) Improve the SPADS database management system
  Integrate DBMS with automatic output
- (3) Investigate the display of improved decision graphics information
- (4) Implementation of a TCT/MICROFIX to SPADS protocol-- for both 8-bit and 16-bit gateways

Task 21: FIELDING OF 16-BIT COMMUNICATIONS GATEWAY STATION:
- (1) Field a 16-bit microcomputer-based communication gateway station
- (2) Install a 16-bit microcomputer-based CGS
- (3) 16-bit CGS training

Task 22: TRANSITION TRAINING AND SUPPORT:

(1) Pre-exercise support and evaluation. Assist commander and staffs in identifying SPADS objectives and performance standards based upon such objectives
(2) Technical support
(3) Post-exercise reports
(4) Training
(5) Documentation--revise User's Manual, produce a free-standing flip card reference set

Task 23: SUPPORT TO I CORPS IN TEAM SPIRIT 84

APPENDIX C

CORPS STAFF MISSION TASK LISTS[1]

A. ASSISTANT CHIEF OF STAFF, G1 MISSION TASK LIST

1. Coordinate personnel service support
2. Perform strength accounting management
3. Manage replacement operations
4. Track task force composition and management of cross attachments
5. Supervise strength accounting and management operations
6. Perform by-name casualty reporting and monitor personnel status changes
7. Monitor awards and decorations program
8. Manage essential personnel actions
9. Supervise the Personnel Accounting Section
10. Provide administrative service support
11. Operate classified/unclassified official mail and message distribution center
12. Provide limited essential reproduction services
13. Supervise the Administrative Services Office
14. Provide financial advice to the commander
15. Provide liaison services between the Area Finance Support Centers
16. Coordinate security, deployment, and logistic support needed for the mobile pay teams
17. Coordinate essential financial operations

---

[1]SOURCE: Ref.7:pp. F-1 - F-48.

B. ASSISTANT CHIEF OF STAFF, G2 MISSION TASK LIST

1. Request maps required for force operations
2. Provide input to the intelligence estimate
3. Establish liaison with US agencies and friendly host country
4. Prepare the Intelligence Annex to the OPLAN/OPORD
5. Task organize resources to satisfy mission requirements
6. Request tactical transportation for Military Intelligence assets
7. Execute deployment
8. Employ long-range surveillance detachment
9. Plan for aerial intelligence support for the rear, close-in, and deep batties
10. Develop a security plan
11. Monitor the intelligence effort
12. Collect and dispose of captured enemy materiel and equipment.
13. Process combat information from maneuver elements and intelligence products from main CP
14. Analyze incoming information from maneuver elements in conjunction with intelligence received from the main CP
15. Disseminate combat information and combat intelligence
16. Maintain the collection plan
17. Process incoming collection results
18. Establish and maintain counterintelligence technical data bases
19. Provide tactical deception support
20. Process reports
21. Issue an EW estimate
22. Develop an EW annex to the OPLAN/OPORD
23. Establish EW section operations
24. Process incoming intelligence information

25. Modify ECM and ESM using data base and commander's PIR/IR

26. Establish and control EW activities

27. Evaluate effectiveness of friendly EW against the enemy

28. Prepare the Intelligence Estimate

29. Prepare the Intelligence Annex to the OPLAN/OPORD

30. Maintain the intelligence data base

31. Process all source information/intelligence

32. Disseminate combat information and combat intelligence to appropriate agencies

33. Develop a data base to support the rear battle

34. Analyze incoming information (from elements operating in the rear area) with information/intelligence received from the main CP

35. Disseminate combat information/intelligence to the rear area

36. Maintain the rear battle asset collection plan

37. Develop and maintain the OPSEC data base

38. Conduct a vulnerability assessment

39. Implement OPSEC measures

40. Update OPSEC plan based on maneuver unit input

C. ASSISTANT CHIEF OF STAFF, G3 MISSION TASK LIST

1. Plan and coordinate combat operations:

    - Conduct mission analysis
    - Prepare the Operation Estimate
    - Develop the OPORD
    - Recommend the task organization and assign missions to subordinate units
    - Recommend augmentation force requirements

- Supervise fire support planning
- Plan for employment of nuclear and chemical weapons
- Plan for employment of EW
- Supervise ADA fire support planning
- Plan and coordinate tactical air (TACAIR) support
- Plan utilization of airspace
- Integrate engineer support into tactical operations
- Integrate PSYOP and combat operations

2. Control and coordinate combat operations:
   - Maintain a current operations estimate
   - Maintain the current friendly situation and unit status
   - Coordinate immediate close air support (CAS) request
   - Plan for Joint Air Attack Team (JAAT) operations
   - Supervise the preparation of fragmentary orders (FRAGOs)
   - Supervise the coordination of airspace utilization

3. Sustain combat operations:
   - Program and supervise OPSEC activities/programs
   - Incorporate rear battle planning and operations
   - React to enemy chemical or nuclear attack
   - Plan and supervise deception operations

D. ASSISTANT CHIEF OF STAFF, G4 MISSION TASK LIST

1. Provide input to the planning and decision making process:
   - Develop plans
   - Make recommendations
   - Prepare plans and orders

2. Coordinate and monitor supply and operations:

- Maintain information about the status of supplies
- Supervise collection and distribution of excess, salvage and captured material
- Coordinate reception of augmentations

3. Coordinate and monitor field services:

- Monitor status of field service support units
- Coordinate reception of combat service support (CSS) augmentation

4. Coordinate and monitor maintenance operations:

- Maintain records of the status of maintenance
- Coordinate reception of maintenance augmentations

5. Coordinate and monitor transportation services:

- Monitor status of surface and air transportation
- Supervise movements
- Coordinate reception of transportation augmentation

6. Perform command post functions:

- Establish section within the main CP
- Provide augmentation to tactical CP
- Provide augmentation to rear CP

7. Perform staff coordination in other functional areas:

- Monitor personnel activities
- Monitor intelligence activities
- Monitor type of tactical operations

E. ASSISTANT CHIEF OF STAFF, G5 MISSION TASK LIST

1. Assist in the acquisition of local resources, facilities, and support

2. Minimize local population interference with U.S. military operations

3. Prepare an area assessment:

    - Establish liaison with national officials

    - Determine area resources available for mission

4. Advise the commander on civil military operations (CMO):

    - Formulate CMO plans applicable throughout the area of operations

    - Provide for liaison to subordinate units

    - Recommend policies and procedures for civil affairs (CA) activities for command support in area of operations

5. Advise commander on CA governmental functions in operation under the control of other agencies in the area of operation

6. Provide the necessary CMO input into all operational and administrative/logistic plans and orders

7. Advise the commander on the impact of PSYOP on the civilian population

F. AIR DEFENSE ARTILLERY SECTION MISSION TASK LIST

1. Advise the commander and staff on the air defense operations:

    - Coordinate matters concerning ADA operations

2. Coordinate, integrate, regulate, and identify use/users of Army airspace:

    - Perform Army airspace command and control (A2C2) element functions

G. AIR LIAISON SECTION MISSION TASK LIST

1. Supervise forward air controllers (FACs)

2. Supervise the TACP

3. Advise commander and staff regarding USAF support

4. Coordinate close air support (CAS) with the fire support element

5. Function as a member of the Army airspace command and control (A2C2)

6. Operate air request and tactical air (TACAIR) net

7. Transmit air support requests

H. AVIATION SECTION MISSION TASK LIST

1. Plan aviation combat employment:

   - Advise on and plan aviation cross-FLOT operations
   - Advise on attachments and detachments to subordinate units
   - Plan for aviation augmentation
   - Monitor combat operations

2. Plan aviation combat support operations:

   - Recommend employment of aviation for air logistics
   - Allocate units for air logistics operations
   - Monitor combat support operations

3. Function as a member of the Army airspace command and control (A2C2) element:

   - Coordinate aviation operations with ADA
   - Employ liaison officer to coordinate aviation operations

4. Supervise aviation training and safety:

   - Monitor aviation safety program
   - Monitor crash rescue program
   - Monitor the crew endurance program
   - Monitor the search and rescue program

5. Supervise technical aviation aspects:

   - Monitor the flying-hour program
   - Plan aviation flow and aircraft requirements for strategic deployment of the combat aviation battalion

I. CHEMICAL SECTION MISSION TASK LIST

1. Prepare for chemical section operations:
    - Evaluate the NBC threat
    - Initiate attack record
    - Recommend nuclear observation units
    - Establish situation map and overlays
    - Review NBC defense training program
    - Activate internal NBC SOP
2. Establish chemical section operations:
    - Coordinate with the G2 for NBC data input
    - Conduct vulnerability assessment
    - Prepare NBC estimates
    - Prepare the NBC portion of OPLAN/OPORD.
    - Prepare and disseminate wind message
3. Provide immediate warning of expected contamination:
    - Process reports of attack
    - Prepare prediction of contamination
    - Disseminate warning
    - Prepare immediate damage estimate
4. Evaluate NBC contamination data:
    - Evaluate NBC 4 reports
    - Examine contamination data
    - Select reporting unit for series reports
    - Evaluate series reports
    - Prepare and disseminate NBC 5 reports
5. Maintain unit radiation status:

- Process tactical dosimetry reports

6. Assist in planning the use of nuclear and chemical weapons:

   - Recommend integrating nuclear and chemical fires into the scheme of maneuver
   - Advise on allocation and use of chemical means
   - Plan and supervise chemical target analysis
   - Assist in nuclear target analysis

7. Exercise staff supervision over NBC activities throughout the force

8. Advise commander and staff on NBC matters

J. PROVOST MARSHALL MISSION TASK LIST

1. Supervise and coordinate MP force requirements

2. Plan MP portions of estimates, plans, orders, and reports:

   - Prepare a straggler control plan
   - Prepare a traffic control plan
   - Prepare the MP support annex to the OPORD

3. Conduct area security operations:

   - Plan, coordinate, and supervise area reconnaissance
   - Plan, coordinate, and supervise MP rear battle operations
   - Coordinate and supervise security of designated personnel, units, convoys, facilities, and MSR critical points
   - Coordinate and supervise intelligence collecting and reporting
   - Coordinate and monitor NBC detecting and reporting

4. Conduct battlefield circulation control (BCC) operations:

   - Coordinate and supervise route reconnaissance and surveillance
   - Monitor MSR regulation
   - Plan, coordinate, and supervise straggler/dislocated civilian control

- Monitor information dissemination activities

5. Conduct enemy prisoner of war (EPW) operations:

    - Coordinate and plan for the execution of EPW and CI collection operations
    - Coordinate and monitor EPW processing and evaluation
    - Supervise, monitor, and coordinate central collecting point facilities

6. Conduct MP support to operations requiring special considerations:

    - Plan, coordinate, and supervise MP support to river crossing operations
    - Plan, coordinate, and supervise MP support to military operation in urbanized terrain
    - Plan, coordinate, and supervise MP support to the deep attack

7. Conduct law and order operations when directed by the commander

K. COMMUNICATIONS-ELECTRONICS SECTION MISSION TASK LIST

1. Plan C-E support:

    - Plan C-E support with the staff
    - Prepare the C-E staff estimate
    - Monitor signal equipment status

2. Coordinate C-E support:

    - Coordinate with the staff
    - Coordinate with the signal battalions
    - Coordinate the use and allocation of radio frequencies
    - Coordinate COMSEC and SIGSEC
    - Coordinate with the C-E section of higher and adjacent headquarters

3. Supervise C-E activities:

- Supervise the ECCM program
- Supervise the CEOI

L. ENGINEER SECTION MISSION TASK LIST

1. Plan, coordinate, and supervise mobility, countermobility and survivability operations:

   - Plan and advise supported units on mobility missions
   - Perform estimates using factors of mission, enemy, terrain, troops, and time available (METT-T)
   - Provide recommendations to the maneuver commander on mobility operations
   - Prepare a survivability estimate based on METT-T

M. FIRE SUPPORT ELEMENT MISSION TASK LIST

1. Establish and maintain fire support facilities:

   - Establish continuous fire support planning and coordination facilities
   - Advise the commander and/or G3 on fire support operations and capabilities
   - Communicate
   - Manage fire support coordination reports and information

2. Prepare and coordinate the fire support plan:

   - Prepare the "Fires" portion of the concept of operation paragraph and the fire support paragraph to the OPORD
   - Direct and coordinate the preparation of the fire support plan

3. Plan/coordinate employment of fire support assets:

   - Recommend organization for combat
   - Coordinate and plan the integration of all fire support assets to support the maneuver plan
   - Coordinate with the Army airspace command and control (A2C2) element

4. Process and coordinate target attack:

   - Recommend target attack guidance
   - Process planned fire support requests
   - Expedite immediate fire support requests (tactical FSE)
   - Request target damage assessments

5. Perform target analysis:

   - Perform non-nuclear target analysis
   - Perform nuclear target analysis
   - Schedule nuclear weapons
   - Perform toxic chemical target analysis

6. Employ nuclear weapons:

   - Plan nuclear weapon employment
   - Perform post-strike analysis (main FSE)

N. STAFF WEATHER SECTION MISSION TASK LIST

1. Provide weather support data and recommendations
2. Prepare climatological studies and analysis
3. Evaluate and disseminate weather data

O. HEADQUARTERS COMMANDANT MISSION TASK LIST

1. Provide operational control and planning for the HQ:

   - Supervise the movement of the HQ main CP
   - Supervise the internal arrangement of the HQ main CP

2. Provide essential services:

   - Provide food service, medical support, morale, and supply service to the HQ main CP
   - Plan local security for the HQ main CP

- Supervise the maintenance of HQ equipment

APPENDIX D
MCES METHODOLOGY DESCRIPTION

A. INTRODUCTION

The MCES is a framework for systems planners and analysts to evaluate C2 architectures. It is intended to guide problem specification and analysis, to provide concise conclusions, and enhance decision making. It is composed graphically of seven sequential modules and a "Decision Maker" block [Figure D.1, Ref. 2:p. 7]. The following description is taken in part from Dr. Ricki Sweet, et. al, <u>MCES: Applications of and Expansion to C3 Architectural Evaluation</u> [Ref. 2:pp. 10-23] and Sweet's subsequent publications.

B. MCES MODULES

1. <u>Module 1: Problem Formulation</u>

Module 1 describes the decision maker's objectives and needs for a specific C2 problem. The decisions being formulated, problem assumptions and the level of analysis required are taken into consideration. As a result, both the appropriate scenarios and problem scope are made explicit. Thereafter, the precise statement of the problem is used in the second module to bound the C2 system of interest [Figure D.2, Ref. 2:p. 15]

The objectives of the decision maker posing the problem are addressed from the standpoint of: (1) the life cycle of the military (C2) system, and (2) the level of analysts prescribed [Ref 2:p. 11]. The decision maker's objectives generally mirror the various phases of the life cycle of a military system, namely: (1) concept definition and/or development; (2) design; (3) acquisition; and (4) operations. The appropriate level of

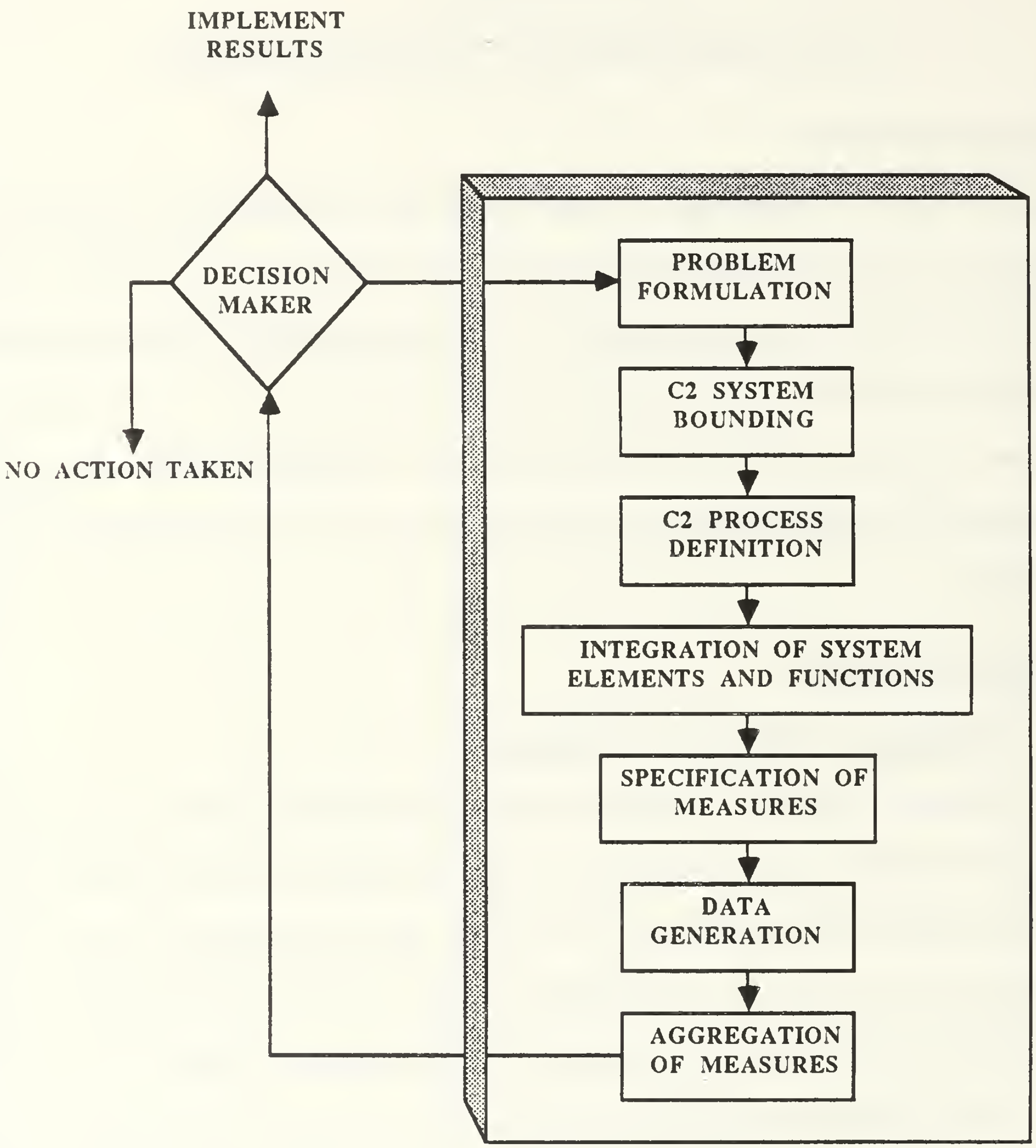

Figure D.1. Modular Command and Control Evaluation Structure

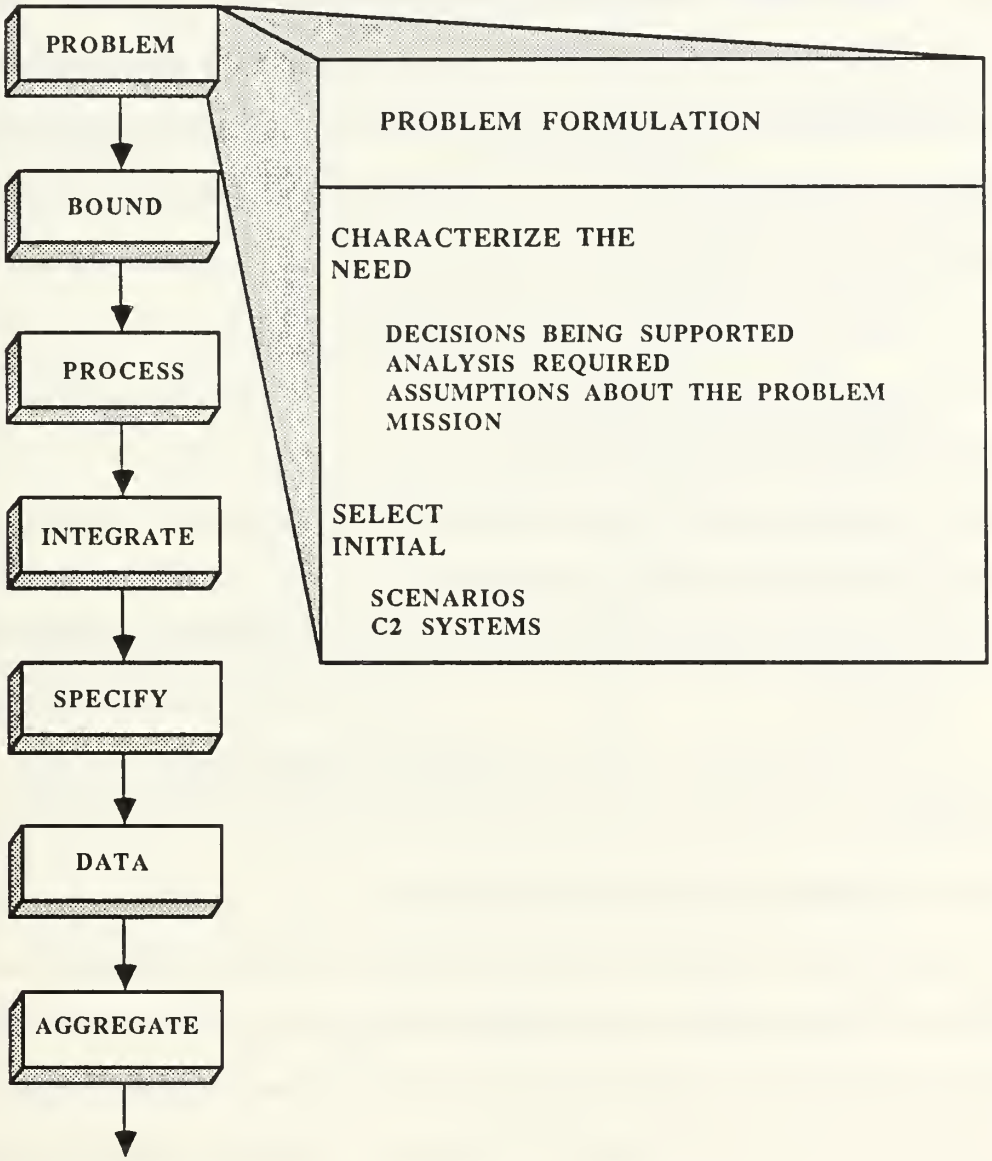

Figure D.2. MCES Problem Formulation

analysis is derived from: (1) the mission the system is addressing, (2) the system itself, or (3) the components of the system or subsystems.

In summary, three steps take place in Module 1: (1) the decision maker's needs, previously known as applications objectives, are characterized; (2) the problem boundaries are selected; and (3) the remaining modules are previewed for their potential impact on the problem statement [Ref. 2:pp. 10-11]. In the implementation steps, several questions provide guidance, namely:

1. What are the assumptions of the application?
2. Are the decisions related to planning or implementation?
3. Does the evaluation apply to an individual C2 system or require a comparative evaluation of several alternatives?
4. What type of analysis of methodology is appropriate?
5. What part of the life cycle of a military system is involved?
6. What mission/service area is involved?
7. What level (system, subsystem, platform, etc.) is the analysis focused upon?
8. What type of measure, i.e., how quantitative, will answer the decision maker's questions?
9. Who is the decision maker, and how will he/she use the data?
10. Who is the analyst, and what background must he/she have to properly address the evaluation?

2. Module 2: C2 System Bounding

Module 2 identifies the relevant system elements that will bound the system of interest. The primary goal is to delineate the difference between the system being analyzed and its environment. To bound the C2 system, the analyst should employ the three component definition, based upon JCS Publication 1, preliminary to the implementation of this module, of the C2 system. A C2 system consists of: (1) physical entities—equipment, software, people and their associated facilities; (2) structure—organization, procedures, concepts of operation and information flow patterns; and (3) (C2) process—the functionality or "what the system is doing." [Ref. 28:p. 22]

Once the system elements of the problem have been identified and categorized as a result of the deliberations taking place in Module 1 and input into Module 2, the C2 system of interest may be further bounded by relating the "physical entities" and the "structure" components to the graphic representation of the levels of analysis, using the "onion skin" graphic model [Figure D.3, Ref. 2:pp 12-13]. In this module, the C2 system, represented by the hardware and software design specifications, is identified and related to the environmental C2 stimulus. This relationship is developed in terms of establishing boundaries to calibrate the system. [Ref. 2:pp.12-13]

The C2 system statics must be distinguished from the C2 system dynamics, the "C2 Process." The statics may be taken as the physical entities together with the structure of what is needed to perform C2. The physical entities include equipment, software, people, and the facilities that house them. The structure is represented by the arrangement and interrelationships of physical entities in the form of procedures, protocols, concepts of operations and information flow patterns.

3. Module 3: C2 Process Definition

After the system is bounded and the system elements identified, the generic C2 process component of the system is identified. Module 3 forces the analyst's attention on: (1) the environmental "initiator" of the C2 process, which results from a change in the desired state; (2) the internal C2 process functions (sense, assess, generate, select, plan, direct); and (3) the input to and output from the internal C2 process and the environment [Figure D.4, Ref. 2:p. 14].

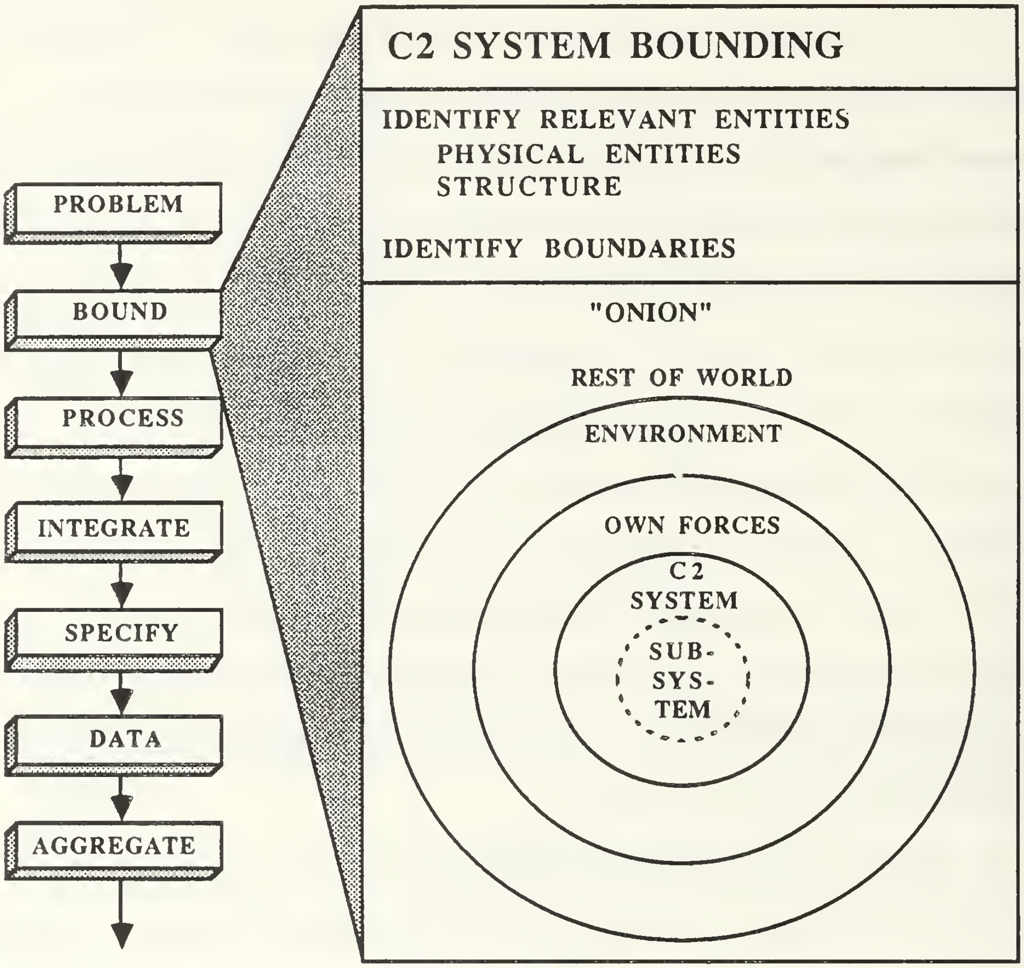

Figure D.3. MCES C2 Systems Bounding

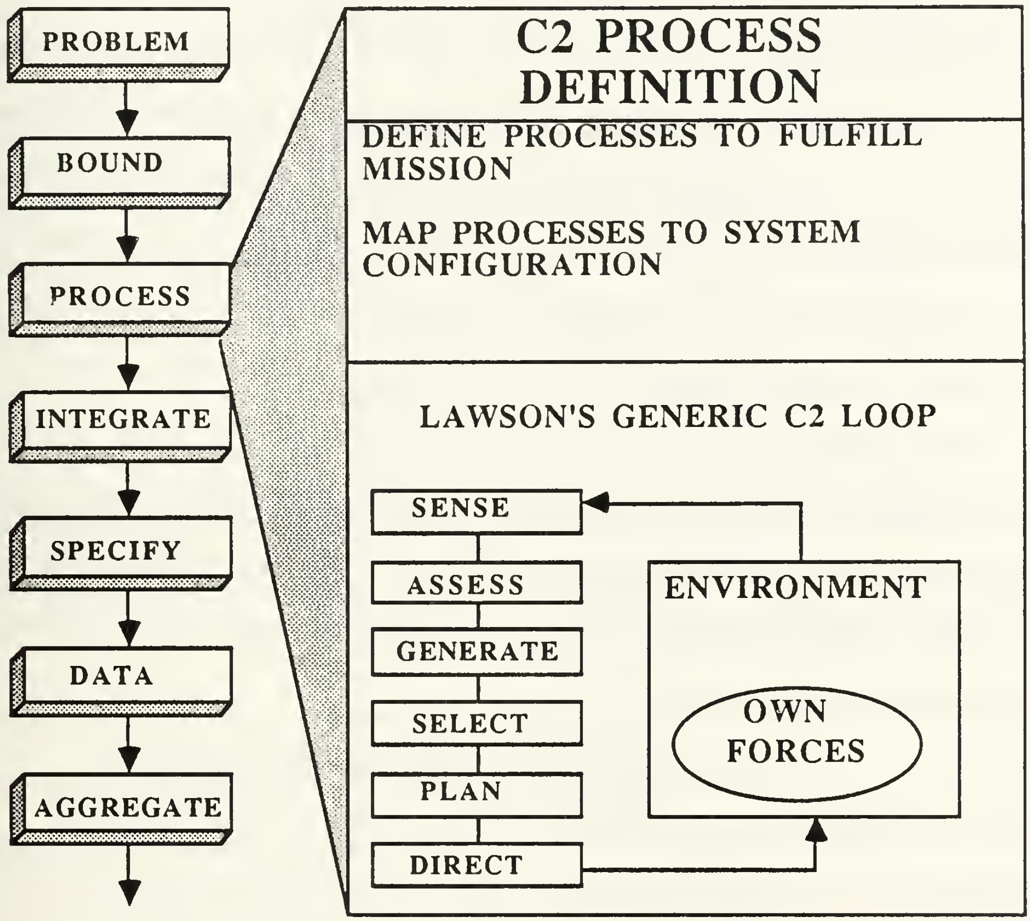

Figure D.4. MCES C2 Process Definition

The C2 Process Definition Module represents the C2 system in several ways:

1. The total (end-to-end) process
2. The boundary of the C2 components vis-a-vis the non-C2 force components
3. The structure, especially time and organization (hierarchical) relationships
4. Internal dynamics
5. Interactions between the C2 system and the environment
6. Information transfer

This definition may help to focus an analysis if several conditions are met, namely, that it is: (1) understood and agreed upon by the decision maker; (2) considered as the basic building block for individual entities of the C2 system of interest; (3) measurable within the bounds of the specified problem; and (4) able to incorporate the functions of all physical entities included within the system being analyzed.

For distributed C2 systems, three factors affect the overall performance: (1) an intelligence process aids decision makers throughout the C2 system in forming perceptions of enemy capabilities and intentions, (2) a separate Crosstell (XTEL) process provides a way to share information for the purpose of improving the overall picture of the environment and improving the accuracy of information, and (3) the C2 process is supported by the two previous processes. In a geographically distributed C2 system, the separate C2 processes associated with separate command posts will be netted together through the XTEL process; the intelligence process will be interfaced with some, but not all, C2 processes. How these processors are interfaced together will be defined by communications links, protocols and operational procedures. These interfaces may be taken as fundamental to the architecture of the C2 system, when the term "architecture" is used to specify the communications support to command and control. [Ref. 2:pp. 70-73]

Another approach in this module may translate the design specifications into a network model of the C2 system to demonstrate the functionality of the C2 system. When

applicable to the analysis being conducted, the functional subsets of the C2 process model should be related to relevant measure is Module 5.

4. Module 4: Integration of System Elements and Functions

Analysis during Module 4 occurs as: (1) the relationships between the physical entities and the structure (defined in Module 2) and the staff functions or processes (described in Module 3) are called out; and then (2) a technique, such as directed graphs, may be used to model the observables, e.g., information flow, that is used to track these relationships. Information flows may be conceptually employed to link the separate processes into an architecture of the complete C2 system. The term "architecture" is used in Module 4 to emphasize the integration of the individual C2 systems—whose physical entities, structures and functions are coherently related—into a set. The form of the C2 architecture is designed to support an evaluation of the mission effectiveness. The final form of the architecture will include the process description and the system elements performing the processes arranged in a structural framework [Figure D.5, Ref. 2:pp. 16-17]

5. Module 5: Specification of Measures

In Module 5, the analyst specifies the measures necessary to address the problem of interest in terms of problem, bounding, process and integration. The components of the C2 system definition may be employed to derive an exhaustive set of relevant measures, which are then subjected to further scrutiny: (1) comparison with a set of criteria, which reduces the number to a more manageable set; (2) these are classified as to their level of measurement—as an alternative, a minimum essential set may be sought rather than an exhaustive grouping; and (3) the resulting measures are used to determine the value added to the C2 system by alternative configurations of the physical entities, structure and/or processes.

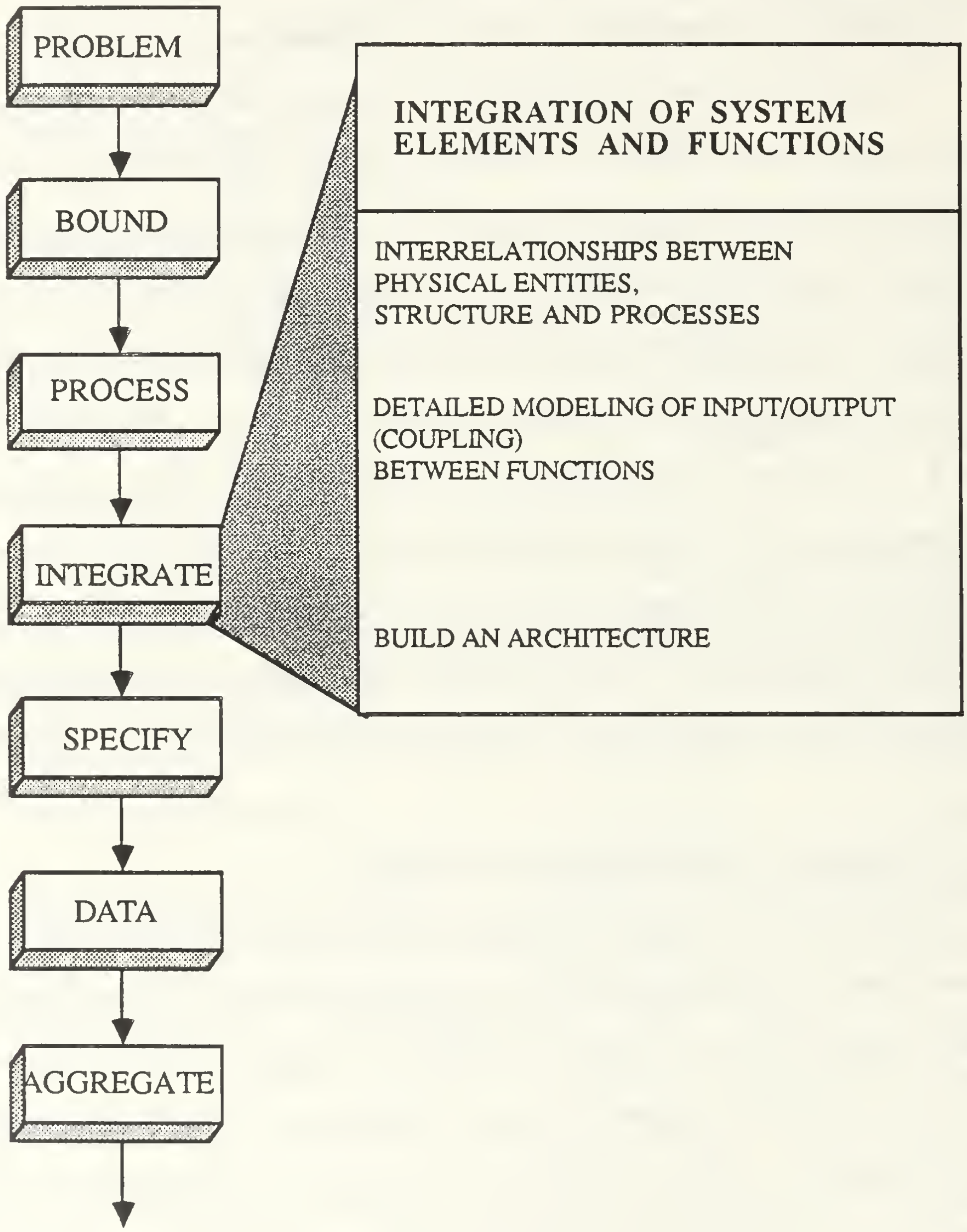

Figure D.5. Integration of Statics and Dynamics

The functional subsets of the C2 process model may be related to relevant measures of performance (MOPs), measures of effectiveness (MOEs), and measures of force effectiveness (MOFEs). The determination of the boundary helps to identify what kinds of measures are necessary; for the boundary between the force and the environment, MOFEs are appropriate. Within the force boundary, MOEs are used. For the subsystem—within the boundary of the system—MOPs should be employed. Within the subsystem, dimensional parameters (DPs) are the relevant descriptive terms. Thereafter, the data generation module objective may be taken as the analysis of the hardware and software system specifications against its design parameters [Figure D.6, Ref. 1:p. 2-4].

The application directly influences the selection of the measures to be used (and ultimately the means of specifying those measures). These applications are the phases of the military life cycle: conceptual, definition, acquisition and operational. The levels of analyses relate to the focus of the evaluation (i.e., on subsystems, systems or missions).

Guidelines are provided in Module 5 to identify, develop and select measures that gauge the C2 system's response in directing forces. These measures will provide a standard for comparison as the underlying architecture of the C2 system is re-configured; they are directly tied to operational issues relating to the architecture. Table D-1 shows the criteria for evaluation measures that may be compared to a set of desired measures to insure that the measures are useable [Ref. 2:p. 19].

6. Module 6: Data Generation

After identifying the measures for functions, the analyst addresses the issue of how data will be generated. Exercises, simulations, experiments and subjective judgments are all examples of data generators [Figure D.7]. Although a data generator may be difficult to conceptualize or build, the output are numeric values for the measures

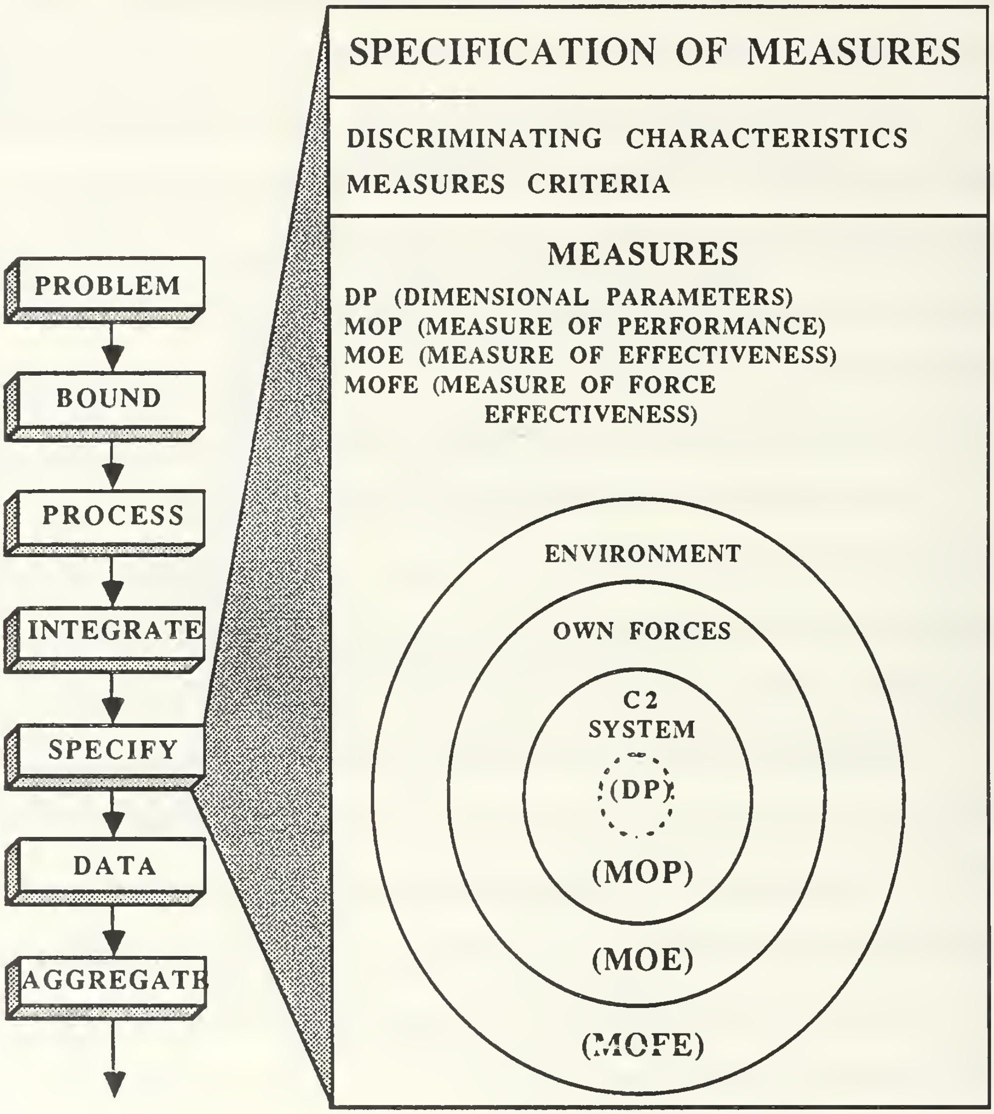

Figure D.6. Specification of Measures

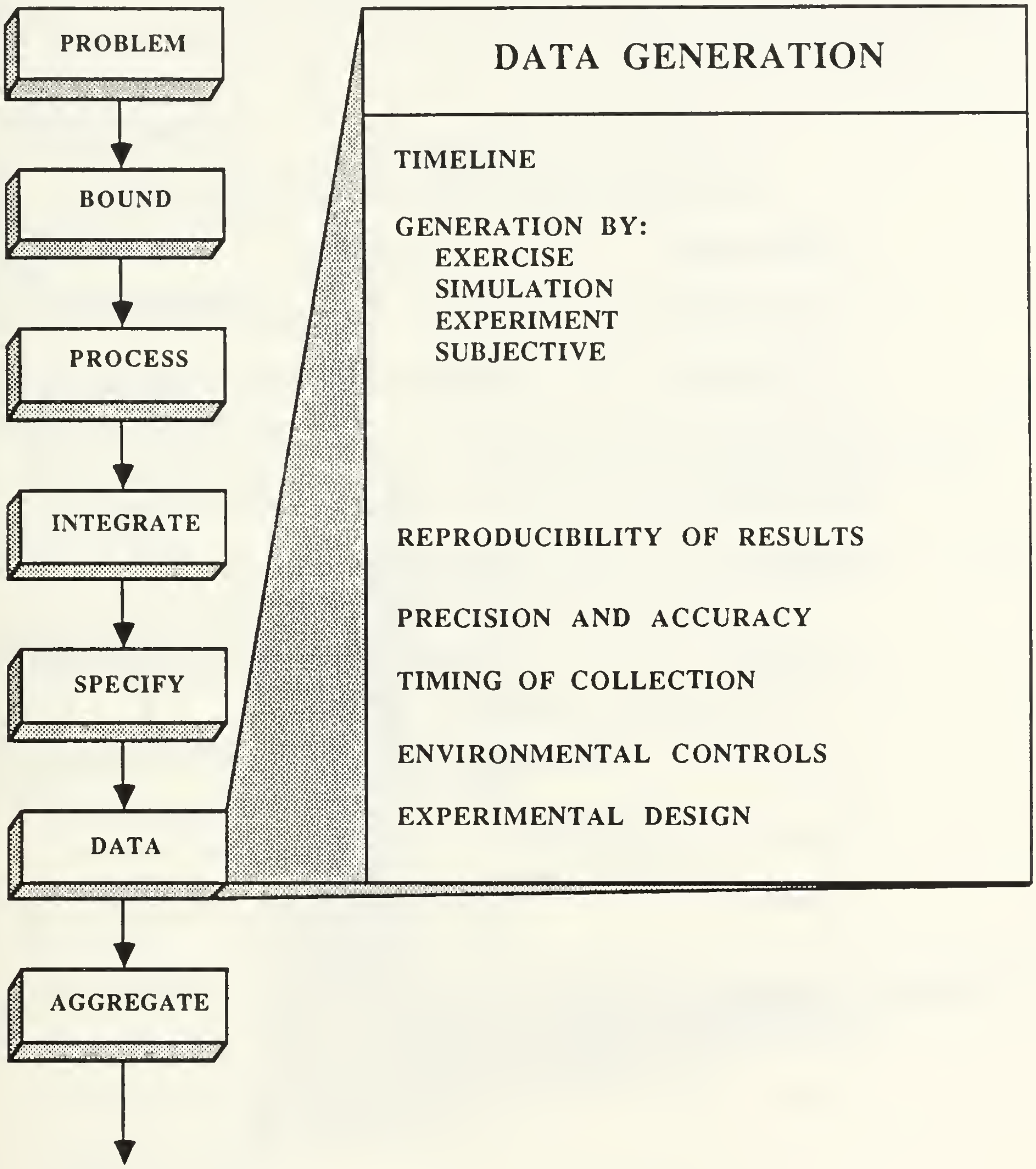

Figure D.7. Data Generation

specified in Module 5. The analyst must consider the following: reproducibility of results, precision and accuracy, timing of collection, environmental controls, and experimental design in Module 6. [Ref. 2:p. 21]

TABLE 25
CRITERIA FOR EVALUATION MEASURES

Characteristics:	Definition:
Mission-oriented	Relates to force/system mission
Discriminatory	Identifies real differences between alternatives
Measurable	Can be computed or estimated
Quantitative	Can be assigned numbers or ranked
Realistic	Relates realistically to the C2 system and associated uncertainties
Objective	Can be defined or derived, independent of subjective opinion
Appropriate	Relates to acceptable standards and analysis objectives
Sensitive	Reflects changes in system variables
Inclusive	Reflects those standards required by the analysis objectives
Independent	Is mutually exclusive with respect to other measures
Simple	Is easily understood by the user

7. Module 7: Aggregation of Measures

From Module 6, Data Generation, the analyst obtains values for the specified measures which will be analyzed in this module [Figure D.8]. Because varying scenarios may be important for each iteration of the MCES, the analyst must determine the important

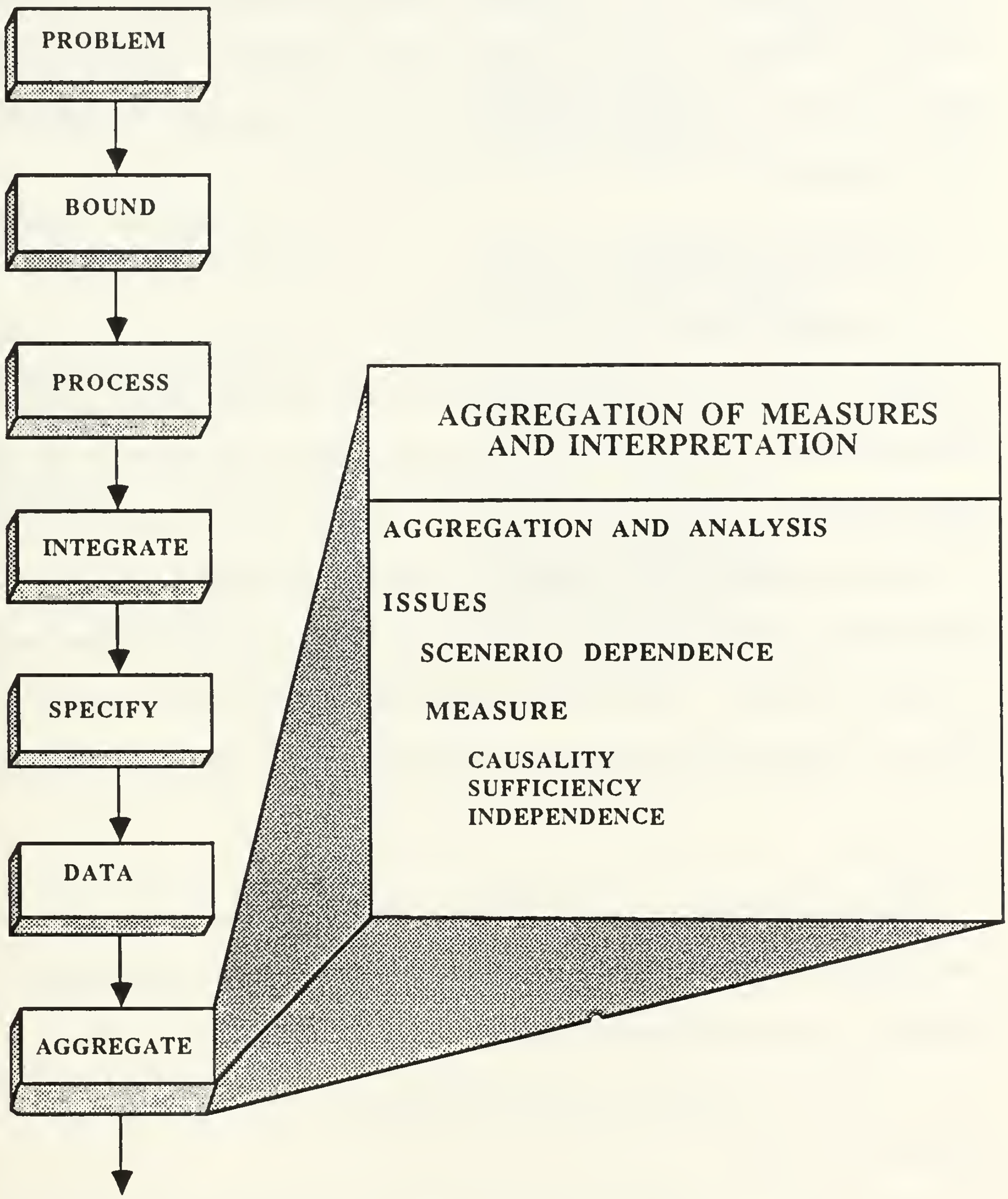

Figure D.8. Aggregation and Interpretation of Measures

factors in each. Techniques are provided within MCES to aggregate measures in a way that relates measurement of the C2 response to combat outcome. Next, the issues of measure causality, sufficiency and independence must be considered. Finally, the analyst must decide if the decision maker's original queries can be addressed by the MCES analysis. [Ref. 2:pp. 21-22]

C. DECISION MAKER

The products derived from the MCES analysis are presented to a decision maker. Generally, there are three courses of action available. First, the results of the analysis may be implemented. Second, the decision maker may require a re-iteration of the MCES based upon the need for further study. Finally, the process may be terminated. The MCES does not contain a specific decision process. The decision maker's analysis of the MCES products may be entirely subjective; objective, based upon the numerical values; or any combination of these. MCES only specifies the framework of the logical evaluation process. It remains with the decision maker to reach a final conclusion. [Ref. 39:pp. 18]

D. USES

MCES can provide a comprehensive framework for the areas of C2 analysis and management. MCES clarifies the specification of problems by systematically focusing on and indentifying the essential characteristics of C2 systems and architectures. MCES assists analysts to effectively conduct C2 evaluations for the decision maker and operational user. [Ref. 29:p. 26]]

Table 26 shows examples of the many uses of the MCES output [Ref. 30:p. 23].

TABLE 26
MCES APPLICATIONS

Application	Examples
Design and evaluation	Command centers Operational concepts Information flows Protocols and priorities
Development of test plans for analysis and evaluation	Testbed experimentation Integration of new equipment Integration of new missions
Evaluation of essential MOEs	Interoperability Survivability Maintainability
Master planning	Capability evaluation Requirement analysis Deficiency identification Acquisition requirements Programming priorities

APPENDIX E
DEFINING THE FORWARD DEPLOYED CORPS

A. GENERAL

The corps is the U.S. Army's largest maneuver unit; it is the focal point for fighting the AirLand Battle. The corps is organized to perform major operational and tactical tasks; it takes an active part in directing campaigns and fighting battles [Ref. 3:p. 1-1]. Generally, a corps consists of two to five divisions, a combat aviation group, corps artillery, and a corps support command as well as a large number of separate combat, combat support, and combat service support units. Based on mission and location, a corps is normally classified as either contingency or forward deployed [Ref. 31:p. 1-6].

The forward deployed corps exists only in Europe [Ref.31:p. 2-1]. It controls combined arms forces and maintains those forces in a high state of combat readiness. The corps has established command relationships, defined missions, assigned areas of responsibility, and established logistics facilities. It receives some support from the host nation and is affiliated with units in the United States that are designated for quick deployment as reinforcements in wartime [Ref. 31:p. 1-6].

B. HIERARCHICAL RELATIONSHIPS

1. Superior

The forward deployed corps is subordinate to the theater army. In West Germany, the Central Army Group is composed of two U.S. and two German corps. Each corps has two to five assigned divisions.

2. Corps Lateral Structure

The peacetime headquarters of the forward deployed corps is structured to perform normal staff operating functions in the peacetime headquarters building. In wartime, the demands for coordination of staff effort require that the headquarters be functionally organized into command posts; these command posts are further subdivided into functional modules or cells. This reorganization facilitates communication among those staff elements that must interact frequently. [Ref. 6:pp. 2-10, 2-11]

3. Subordinate

The corps is made up of combat, combat support, and combat service support units. The commanders of the corps' principal maneuver units (divisions, regiments, and separate brigades) direct the combat activities of their immediate subordinate maneuver units. To the greatest extent possible, all routine operations that support the corps are controlled through staff channels, leaving the maneuver commanders free to direct their forces. [Ref. 3:p. 3-5]

The combat units of the forward deployed corps are the armored and mechanized divisions, the armored cavalry regiment, the combat aviation group, the two artillery brigades, and the engineer brigade. Due to the mobility, firepower, and survivability of the armored and mechanized divisions, they are best employed where combat will take place over wide areas. The armored cavalry regiment has both air and armor units which operate as a combined arms team over a wide area of the battlefield. The combat aviation group provides an air attack capability in support of the corps mission. The artillery brigades are designed to suppress, neutralize, or destroy enemy targets. The engineer brigade performs three battlefield missions: mobility, countermobility, and survivability. [Ref. 31:pp. 1-14 - 1-19]

The combat support units of the forward deployed corps are the signal brigade, the military police brigade, the military intelligence group, the chemical brigade, and the rear area operations center. The signal brigade provides communications-electronics support for the corps and its major subordinate commands. The military police brigade has three battlefield missions: battlefield circulation control, area security, and control of enemy prisoners of war. The military intelligence group: provides all source intelligence products to the elements of the corps and its subordinate commands; conducts signal intelligence (SIGINT), imagery intelligence (IMINT), and human intelligence (HUMINT) collection operations; conducts electronic warfare missions; and provides operations security support to the corps and its subordinate commands. The chemical brigade provides nuclear, biological, and chemical defense support to the corps and its subordinate commands. The rear area operations center executes and manages the corps rear battle. [Ref. 31:pp. 1-22 - 1-25]

The corps support command (COSCOM) serves combat service support needs by providing for personnel, administrative, logistical, and medical needs of the corps [Ref. 45:p. 1-25]. COSCOM's functions are supply, maintenance, manning, transportation, field services, administration, reconstitution, and rear area protection [Ref. 3:p 7-1].

C. OPERATIONAL CONCEPT

1. Overview

Corps operations generally consist of phases which can be characterized as offensive or defensive. Our national strategy dictates that the initial phase of operations for a forward deployed corps will be defensive. The AirLand Battle doctrine provides the opportunities for commanders to seize the initiative in local defensive actions. Follow-on operations will be based upon exploitation of these opportunities to support achievement of the corps campaign plan. [Ref. 31:p 1-3]

The forward deployed corps fights the major battles of a campaign. The corps commander directs the tactical operations of subordinate divisions, separate brigades, and regiments to achieve the operational objectives. The corps integrates the air support from other services to support these tactical operations. [Ref. 31pp. 1-4 -1-5]

The corps operational concept, whether attacking or defending, is to defeat the enemy by securing, retaining, and aggressively exercising the initiative. [Ref. 31:p. 3-15]

2. The Three Battles

The corps simultaneously fights three battles. The specific objectives of the rear, close-in, and deep battles support the objectives of that phase. The objective of the rear is to retain the corps' freedom of action. The objective of the close-in battle in the offensive phase is the complete destruction of enemy divisions at the Foward Line of Own Troops (FLOT); the objective in the defense is to retain terrain and defeat enemy forces. The objectives of the deep battle in the offense are to deny the enemy freedom of action and to destroy second echelon divisions; the objectives in the defensive phase are to disrupt the enemy forward flow at critical times, to alter the enemy commitment plan, and to find enemy operational echelons. [Ref. 31:p. 1-3]

3. Offense

The primary purpose of offensive operations is to defeat the enemy by disrupting and destroying both his forces and their support. The corps executes offensive operations when the commander seizes an opportunity to take the initiative or when the theater army orders the offensive. These operations are characterized by aggressive initiative on the part of subordinate combat commanders, by timely shifts in the main effort to seize opportunities, by momentum, and by the deepest and most rapid destruction of enemy forces possible. [Ref. 3:pp. 5-1 - 5-3]

4. Defense

The forward deployed corps and its allies will be defending at the onset of war because of our national strategy and the defensive character of our alliances. The underlying purpose of all defensive operations is to seize the opportunity to change to the initiative. By simultaneously fighting the close-in battle and the follow-on forces, the forward deployed corps creates opportunities to seize the initiative. The corps commander must follow Napoleon's concise requirements of the defense:

> The whole art of war consists in a well-reasoned and extremely circumspect defense, followed by rapid and audacious attack. [Ref. 3:p 6-1]

The objective of the defense is to create the conditions that allow the corps to withstand the initial shock of the enemy attack, to halt the enemy forces, to seize the initiative, and to go on the offensive. [Ref. 3:pp. 6-1 -6-2]

5. Command, Control and Communications Countermeasures

Command, control and communications countermeasures (C3CM) must be fully integrated into the corps' operations to preserve the capability of effective command and control. C3CM is the integrated use of operations security, military deception, jamming, and physical destruction—supported by intelligence—to influence, degrade, or destroy adversary C3 capabilities and to protect friendly C3 from similar enemy actions. The full participation of all corps units is required for the C3CM effort. The commander has the opportunity to seize the initiative and retain it if C3CM efforts are used to disrupt enemy C3 and slow his decision cycle. [Ref. 31:p. 4-28]

D. THE THREAT

1. Warsaw Pact

The most serious threat to the forward deployed corps is the Soviet heavy maneuver force. The Soviet principle of heavy maneuver warfare is based on violent,

sustained, and deep offensive action. Soviet doctrine dictates that mechanized and armored formations, supported by aviation, artillery, and air defense, must seize the initiative at the outset of war, penetrate NATO defenses, and then drive decisively and deeply into the rear areas. [Ref. 3:pp. 2-2 - 2-4]

At the operational level of war, the Soviets aim to defeat the forward deployed corps throughout the theater of operations. Their operational concept is to attack in force to such a depth in the entire corps area of operations that defense becomes impossible. To provide operational leverage in defeating the corps, the Soviet army commander will introduce second echelon forces and/or operational maneuver groups and deliver nuclear, biological, or chemical fires. [Ref. 31:pp. 2-1 - 2-2]

The Soviet forces are echeloned in depth to maintain a rapid advance. The army first echelon is made up of motorized rifle and tank divisions. This echelon will attempt to attack, penetrate the corps' forward defenses, and neutralize or destroy friendly forces up to the assigned mission objective. The second echelon contains tank divisions and/or motorized rifle divisions. It attempts to exploit through the penetration area to its subsequent objective, the corps reserves. [Ref. 3:p. 2-5]

The Soviet operational maneuver group (OMG) is made up of combined arms and tank armies; it may be as large as a reinforced maneuver division. When this force is deployed, it attempts to attack at high speed along a separate axis to seize or destroy deep objectives. Likely targets for OMG are the corps nuclear weapons, reserve forces, airfields, key terrain, and/or political and economic centers. The OMG is normally introduced before the first echelon battle is completed and before the second echelon is committed. [Ref. 31:p. 2-2]

A major focus of Soviet doctrine is the disruption of the corps rear area activities. These operations will range from acts of sabotage and assassination to large-scale

insertions of airborne or airmobile units as well as an operational maneuver group. Likely targets of these forces are C2 centers, communications facilities, logistics facilities, airfields, and reserve forces. These disruptions may be carried out throughout the corps rear area. [Ref. 3:pp. 2-8 - 2-9]

2. Nuclear and Chemical Environment

The corps must operate with the knowledge that nuclear, biological, or chemical weapons may be used by the Soviets at any time. In the nuclear environment, the corps must balance the tactical requirement to mass its forces with the survival requirement to disperse them. Special efforts must be conducted to conceal or deceive the actual locations of critical units and facilities. [Ref. 31:pp. 3-40 - 3-43]

Command and control facilities and procedures must be robust enough to withstand periods of intense communications degradation without major disruption of the corps' operational momentum. Command posts will have to maintain dispersion and move frequently to ensure survival. Command and control will have to be maintained even when some headquarters are destroyed. Redundant C2 facilities are required to maintain continuity of command. [Ref. 3:pp. 2-19 - 2-20]

3. Electronic Warfare Environment

Soviet radio electronic combat (REC) will pose significant problems for the corps and its subordinate forces. Soviet REC units collect combat information by monitoring; once they have located and identified critical radio stations, they will attempt to deceive or exploit them, disrupt their communications, or destroy them with artillery fire. [Ref. 31:pp. 2-12 - 2-13]

Defensive electronic warfare efforts will be critical to friendly use of the electromagnetic spectrum. The communications-electronics operating instructions (CEOI) must be used by all friendly forces to maintain continuity of operations. Frequent

displacement of corps and divisional CPs will provide certain protection for command facilities and key personnel. [Ref. 3:pp. 2-21 - 2-23]

E. CORPS COMMANDER AND STAFF

1. Commander

To effectively fight the corps' battles, the commander must position himself to command and control his forces. Depending upon the particular circumstances of the battle, he may choose to command from one of his own CPs, from a division CP, or from a forward vantage point on the battlefield. The commander must have immediate access to information throughout the width and depth of the corps area of operations to synchronize the corps war fighting capability. [Ref. 3:pp. 3-9 - 3-10]

The corps commander must "think" brigades and "fight" divisions. He anticipates the battle 24 to 96 hours in the future. He influences the battle by dividing the battlefield, allocating assets, establishing priorities, and synchronizing the AirLand Battle. The corps commander has the assets to move forces on the battlefield in order to position them to gain distinct operational or tactical advantage over the enemy. [Ref. 3:p. 2-2]

The commander provides the direction for the corps. He establishes the corps plan to drive operational and tactical planning throughout the corps. With the support of his staff, the commander defines the corps mission, sets its objectives, designs the concept of operation, communicates his intent, assigns missions, and allocates the resources for those missions. [Ref. 31:pp. 4-5 - 4-7]

Clearly one of the primary purposes of the corps command and control system is to support the commander in the exercise of command. While each commander uses his own command style, all commanders must perform the critical functions shown in Table 27 [Ref. 6:pp. F-2 - F-3].

2. Staff

Common functions of the corps staff are to obtain and provide information, to estimate and anticipate the situation, to recommend courses of action, to prepare plans and orders, to supervise execution, and to coordinate operations. (Specific staff functions are detailed in Mission Task Lists found in Appendix C). The corps staff must be capable of: continuous operations; operating from multiple sites and during displacements; continuous communications with higher and lower forces; timely reception, analysis, and presentation of information that is critical to the commander; simultaneous conduct of current tactical operations, planning for future operations, and long-term force support tasks; and effective liaison with other services, allied forces, and adjacent corps. [Ref. 3:p. 3-8]

TABLE 27
MISSION TASK LIST: CORPS COMMANDER

1. Know the situation:
   - See the battlefield
   - Define mission
2. Make decisions:
   - Provide commander's intent
   - Request necessary augmentation
3. Assign missions:
   - Design concept of operations
   - Apply imperatives of combat
4. Allocate means:
   - Employ augmentation force
   - Weight main effort
   - Delegate authority
   - Fight the deep battle
5. Direct the force:
   - Synchronize force efforts
   - Fight the deep battle
   - Concentrate/shift combat powers
   - Maintain momentum
   - Commit reserve
   - Deceive the enemy
6. Maintain the force:
   - Direct combat service support priorities
   - Protect the force
   - Establish reconstitution priorities
7. Motivate the force:
   - Provide personal leadership
   - Reward performance
   - Promote discipline

The commander requires assistance to assimilate the information provided through the corps command and control system. He needs support to filter available information, demand more when the picture of the situation is not complete, analyze pertinent facts, and communicate decisions to the many people that must thoroughly understand the commander's intent. The staff directs and coordinates execution of the commander's intent by providing the necessary control of the battle. Table 28 shows those critical functions performed by the staff [Ref. 6:p. F-8]. (Appendix C specifies those tasks completed by each staff section in the corps CP.)

3. Information Flow Patterns

Information to support the commander's decision making process lies at the heart of the command and control process. Controlling the information in the corps headquarters is a critical task. Procedures must be fully defined to ensure effective control, flow, and processing of the overwhelming volume of information. Positive control of information must be maintained despite the fact that the corps CPs are large, support many concurrent functions, and are frequently spread over a sizable geographic area. [Ref. 31:pp. 4-36 - 4-39]

All information in the corps command posts must be evaluated for accuracy and processed according to consistent guidelines. Unncessary information should be eliminated. Command and control personnel should have easy access to information. Important information should be retained in its original form. All information should be protected against the effects of combat. [Ref. 3:pp. 3-36 - 3-40]

TABLE 28.
COMMON FUNCTIONS OF THE CORPS STAFF

1. Implement and monitor commander's decision and concepts
2. Keep chief of staff informed
3. Collect information
4. Anticipate requirements
5. Make recommendations
6. Collate and analyze information
7. Make estimates
8. Prepare plans and orders
9. Disseminate information
10. Maintain current situation status
11. Develop plans based on missions
12. Communicate plans and orders
13. Ensure units are organized and equipped for combat
14. Implement and update necessary plans and orders
15. Supervise forces/operations to ensure compliance with commander's concept and decisions
16. Analyze and evaluate enemy capabilities
17. Defend against NBC attack
18. Defend against enemy's EW

F. COMMAND POSTS

1. Overview

The corps command post (CP) concept is based on the commander exercising personal control of the battle by using a small, highly trained staff. The commander plays the central role. The purpose of the CPs throughout the corps is to support the commander by providing a structural framework to facilitate his decision making. The staff provides the information and coordination so that the commander can synchronize the deep, close-in,

and rear battles. To support the commander throughout the corps area, the headquarters is normally divided into three command posts: tactical CP, main CP, and rear CP. [Ref. 6:p. 2-1]

The physical and electronic signatures of all corps CPs must be minimized consistent with mission responsibilities. Radios and other emission devices should be remoted from the CPs so that signatures emanate at a distance. Physical and infrared signatures should be reduced or eliminated by siting the CPs in built-up areas. Vehicles, helicopters, and personnel movement must be carefully controlled in the vicinity of all corps command posts. [Ref. 3:pp. 3-30 - 3-31]

2. Tactical Command Post

The orientation of the TAC CP is more limited in scope than that of the main CP. With the focus on the close-in fight, the deep and rear battles are monitored only for their impact on FLOT operations. Planning is narrower in scope and has a shorter timeline—normally only about 24 hours. Because detailed planning and coordination to sustain operations are conducted at the main CP, the TAC CP is small and mobile. Housed in M577 CP vehicles or wheeled vehicles, the TAC CP can operate in a mobile configuration or be dismounted to take advantage of hardened structures. Design of this CP retains 100 percent mobility. The total personnel assigned to the TAC CP should be limited to 100 to 120. This CP relies on mobility and use of terrain and man-made structures for hardening. The physical and electronic signatures should be minimized, and displacements should be planned every 12 to 24 hours. [Ref. 3:pp. 3-24 - 3-25]

The organization of the TAC CP is simpler and more flexible because of the narrower scope. Despite this, a functional organization like that used in the main CP should be used. Command, current operations, intelligence, fire support, logistics, and signal support cells are required. Operation of the TAC CP is normally the responsibility

of either the deputy corps commander or the G3. The functions and organizational structure of the TAC CP are presented in Table 29 [Ref. 3:pp. 3-24 - 3-25].

TABLE 29
THE TACTICAL COMMAND POST

Functions:	Organization of Personnel:
1. Fight the close-in battle.	1. Command cell • Deputy corps commander or G3
2. Develop combat intelligence of immediate interest to the commander.	2. G2/G3 operations team
3. Control maneuver forces.	3. Air liaison team (USAF)
4. Coordinate engineer activities.	4. Fire support team • Assistant corps artillery officer
5. Control and coordinate immediately available fire support.	5. ADA officer
6. Monitor the deep and rear battles.	6. Engineer officer
7. Recommend deep battle actions.	7. G1/G4 representative
8. Coordinate requirements to sustain the force.	
9. Coordinate airspace and forward Air Defense Artillery (ADA) operations.	
10. Communicate Combat Service Support (CSS) requirements to the main CP.	

3. Main Command Post

The main CP directs the C2 system and synchronizes the battle. This CP has a broader orientation and is more forward looking than the other CPs. During this decade the main CP has been reduced in size, partially because of a shift of resources to the TAC CP and partially in recognition of the need to reduce the physical signature. The main CPs

have moved farther to the rear to enhance survivability and to lessen the need to displace frequently. The main CP is 60 to 70 percent mobile, but requires considerable time to displace. The size reduction combined with mobility efforts makes main CPs easier to move. While equipment is provided to operate the CPs in a mobile configuration, the main CP is frequently dismounted to provide increased shelter and space when the situation permits. Dismounting normally increases the time required for displacement. [Ref. 3:pp. 3-26 - 3-28]

Because of the size of the main CP, it must be functionally organized to facilitate staff communication and interaction. Multi-disciplined modules are created to enhance speed and coordination as well as reduce reliance on electronic means of communication for information exchange. Modules required include command, current operations, plans, intelligence, fire support, administrative/logistics, signal support, and CP support (headquarters company). The functions and organizational structure of the main CP are presented in Table 30 [Ref. 3:pp. 3-26 - 3-28].

4. Rear Command Post

Although the rear CP's primary function is sustaining the battle, it must also conduct and control rear area operations. This function entails planning for the rear battle, intelligence preparation of the rear area, terrain management in the corps rear, traffic control, and overall C2 for all administrative and logistic support that takes place in the rear. The rear CP must be prepared to serve as the main CP until the main CP is restored after attack or destruction. [Ref. 3:p. 3-28]

The rear CP consists of the Rear Area Operations Center (RAOC) and members of the coordinating and special staffs. The commander delegates responsibility for operation of the rear CP to the rear battle commander, who is normally the deputy

TABLE 30
THE MAIN COMMAND POST

Functions:

1. Fight the deep battle.
2. Monitor the close-in battle.
3. Monitor the rear battle.
4. Coordinate and allocate resources to sustain the three battles.
5. Plan future deep, close-in and rear battle actions.
6. Collate information for the commander.
7. Provide reports to higher headquarters.
8. Provide a focal point for the development of all-source intelligence.
9. Coordinate requirements for rear protection.
10. Monitor the critical radio nets.

Organization of Personnel:

1. The command group
   - Commander and Chief of Staff
2. Administrative and personnel sections
   - G1 Operations and plans
   - Provost Marshall
3. Operations section
   - G2/G3 operations and plans
   - NBC
   - EW
   - OPSEC management
4. CTOC Support Element (CTOCSE)
   - Collection, management and dissemination section
   - Intelligence production section
   - Imagery interpretation section
5. Logistics section
   - G4 operations and plans
   - Transportation section
6. Civil-military operations section
   - G5 cell
7. Fire support element
   - Artillery, tactical air, naval gunfire coordination elements
8. Air space management element
   - ADA and aviation representatives
9. Engineer element
10. Communications center
11. Support troops
    - Signal, military police, aviation, NBC and air defense troops
12. Liaison elements
13. Headquarters commandant

TABLE 31
THE REAR COMMAND POST

Functions:	Organization of Personnel:
1. Fight the rear battle.	1. Command cell • Deputy corps commander assisted by deputy chief of staff
2. Monitor and support the deep and close-in battles.	2. G1 administrative cell
3. Monitor and control all rear area protection efforts.	3. G4 • Logistics, field service and transportation cells
4. Keep the commander and staff informed.	4. G5
5. Provide combat service support (CSS) functions.	5. Provost marshall
6. Monitor counterintelligence and prisoner of war interrogation.	6. Staff judge advocate
7. Monitor military police and provost marshall activities.	7. Chaplain
8. Provide airlift support information and coordination.	8. Public affairs office
9. Sustain the three battles.	9. Inspector general
	10. Adjutant general • Corps personnel operations center

commander, the COSCOM commander or a separate brigade commander. The functions and organizational structure of the Rear CP are presented in Table 31. [Ref. 3:p. 3-28]

G. COMMUNICATIONS

1. Corps

The corps signal brigade is responsible for the installation, operation, and maintenance of reliable, responsive, and redundant communications to all its major

subordinate commands as well as to other selected combat and combat support commands within the corps area of operations. As corps communications-electronics (C-E) officer, the signal brigade commander advises the corps commander on all signal matters and exercises technical supervision over all C-E activities. The signal brigade employs a variety of communications means to support the corps. These means are: multichannel radio, FM retransmission, radio/landline teletypewriter, cable/wire, facsimile, and air/motor messenger service. [Ref. 6:pp. 4-16 - 4-20]

The corps area of operations is extensive. For a fully manned, forward deployed corps, the number of nondivisional troops in this area is approximately 120,000. The corps signal brigade has more than 5,000 personnel, 1,300 vehicles, 500 shelter-housed signal assemblages, and over 2,600 kilometers of wire and cable. It supports about 150 battalion-sized units spread over diverse terrain. The environment of the corps signal brigade includes enemy activity, electronic warfare, and the dynamics of the integrated battlefield. [Ref. 3:p. C-1]

2. External Interfaces

Corps communications are unique because the corps is the interface between theater and tactical communications systems. In the European theater, theater communications are provided to the corps by the Army theater communications command. This provides the corps access to Department of Defense (DOD) systems, including the Automatic Digital Network (AUTODIN), the Automatic Voice Network (AUTOVON), the Automatic Secure Voice Communications System (AUTOSEVCOM), and the Worldwide Military Command and Control System (WWMCCS). [Ref. 3:p. C-3]

LIST OF REFERENCES

1. Sweet, R., Metersky, M., and Sovereign, M., Command and Control Evaluation Workshop, Military Operations Research Society, Command and Control Measures of Effectiveness Workshop, Naval Postgraduate School, Monterey, CA, January 1985 (Revised June, 1986).

2 Sweet, Ricki, et al., The Modular Command and Control Evaluation Structure (MCES): Applications of and Expansion to C3 Architectural Evaluation, Naval Postgraduate School, Monterey, CA, September 1986.

3. US Army Command and General Staff College, Field Circular 100-15, Corps Operations, Fort Leavenworth, KS, March 1984.

4. US Army, HQ, V Corps, Message to DNA, Subject: Apple Microcomputer Expansion, 8 May 1981.

5. Hirsch, Edward, "Evolutionary Acquisition of Command and Control Systems: Becoming a Reality," Signal, pp. 23-26, March 1988.

6. US Army, HQ, V Corps, Letter of Instruction: V Corps Dispersed Command Post, Frankfurt, West Germany, February 6, 1985.

7. US Army Command and General Staff College, Field Circular 101-55, Corps and Division Command and Control, Fort Leavenworth, KS, February 1985.

8. BDM Corp., Inc., Exploratory Development Program (EDP) in Support of TNF C3 Survivability (Support of V Corps/8 ID Dispersed Command Post) After Actions and Lessons Learned Report, McLean, VA, September 1985.

9. Sweet, R. and Armando, L., "Testing, the Modular C2 Evaluation Structure and the Acquisition Process," Signal, pp. 75-9, August 1987.

10. BDM Corp., Inc., Caravan Guard III SPADS Communications Analysis, McLean, VA, August 1982.

11. BDM Corp., Inc., Caravan Guard Lesson Learned Report, McLean, VA, August 19, 1982.

12. McGrew, D. and Jutte, M., "Battle Staff Process of the Dispersed Command Post Integrated with SPADS," OE Communique, pp. 21-2, No. 3, 1982.

13. Army Research Institute (ARI) for Behavioral and Social Sciences, Guidelines for Automating Command and Control Functions in Field Units, Bethesda, MD, March 1984.

14. BDM Corp., Inc., Lessons Learned Report for REFORGER 82, McLean, VA, October 1982.

15. BDM Corp., Inc., Lessons Learned for Able Archer '82, McLean, VA, November 1982.

16. BDM Corp., Inc., WINTEX 83 After Actions Report, McLean, VA, May 3, 1983.

17. BDM Corp., Inc., Caravan Guard IV After Actions Report, McLean, VA, August 10, 1983.

18. BDM Corp.,Inc., After Action Report, 8th ID Support, McLean, VA, January 24, 1983.

19. US Army, HQ, V Corps, SPADS System Manager's Manual (Operator and Organizational Maintenance Manual), Frankfurt, West Germany, March 1984.

20. US Army, 8th Infantry Division, Reforger Statement of Work, Bad Kreuznach, West Germany, 29 June 1984.

21. BDM Corp., Inc., Technical Report, Exploratory Development Program (EDP) in Support of TNF C3 Survivability (Support of V Corps/8 ID Dispersed Command Post), McLean, VA, June 1986.

22. US Army, TRADOC Combined Arms Test Activity, Test Report RS 202, Staff Planning and Decision Support System (SPADS) Observation, Final Report, Fort Hood, TX, June 1985.

23. US Army, HQ, V Corps, V Corps Command and Control (C2) Initiatives Office: Missions, Goals, Functions and Organization , Frankfurt, West Germany, November 23, 1983.

24. US Army, HQ, V Corps, Letter of Instruction - Establishment of the V Corps Command and Control Initiatives Office (C2IO), Frankfurt, West Germany, June 1984.

25. McNair, C., "A User's View: NDI Acquisitions, Signal, pp. 52-57, August 1984.

26. Riedl, P., "Evolutionary Development of C3I Systems, Signal, pp. 60-66, July 1984.

27. Hoffer, Nicholas, Application and Expansion of the Modular Command and Control Evaluation Structure (MCES) as a Framework for Acquisition Management, M.S. Thesis, Naval Postgraduate School, Monterey, CA, March 1987.

28. Kramer, Gail, Application of the Modular Command and Control Evaluation Structure to a Strategic Defense Initiative Command and Control System, M.S. Thesis, Naval Postgraduate School, Monterey, CA, March 1987.

29. Moss, Larry, An Analysis of the Modular Command and Control Evaluation Structure (MCES) Application to the Identification Friend, Foe or Neutral (IFFN) Joint Testbed, M.S. Thesis, Naval Postgraduate School, Monterey, CA, March 1987.

30. Sweet, Ricki, and Levis, Alexander, "The MCES as a Tool for the Evaluation of C3 Systems," FTD/NPS C3 Workshop, Naval Postgraduate School, Monterey, CA, November 1987.

31. US Army Command and General Staff College, Field Manual 100-15, Corps Operations (Final Draft), Fort Leavenworth, KS, February 1985.

BIBLIOGRAPHY

1. BDM Corp., Inc., Vol. I, BDM Technical Proposal for an Exploratory Development Program in Support of TNF C3 Survivability, McLean, VA, June 29, 1981.

2. BDM Corp., Inc., Staff Planning and Decision Support System, McLean, VA, December 7, 1981.

3. BDM Corp., Inc., Training for the Staff Planning and Decision Support System, McLean, VA, April 1982.

4. BDM Corp., Inc., Transportable Concepts and Development Activities, McLean, VA, June 1982.

5. BDM Corp., Inc., Staff Planning and Decision Support (SPADS) System - Hardware Description, McLean, VA, June 1982.

6. BDM Corp., Inc., FY 83 Dispersed Command Post Program for Nuclear Survivability, McLean, VA, August 19,1982.

7. BDM Corp., Inc., Continued Support for the Dispersed Command Post Experiment, McLean, VA, December 17, 1982.

8. BDM Corp., Inc., SPADS Staff Officer's Manual, McLean, VA, January 1983.

9. BDM Corp., Inc., Technical Proposal On-Site Support for the Dispersed Command Post Program (DCP), McLean, VA, June 17, 1983.

10. BDM Corp., Inc., FY 84 Continued Support for the Dispersed Command Post Experiment, McLean, VA, July 5, 1983.

11. BDM Corp., Inc., Revised Proposal for Continued Support of the Dispersed Command Post Program (Ref. Dec 17, '82), McLean, VA, August 10, 1983.

12. BDM Corp., Inc., Exploratory Development Program (EDP) in Support of TNF C3 Survivability (Support of V Corps/8 ID Dispersed Command Post) Summary Letter Addendum to the Final Report, McLean, VA, September 30, 1985.

13. Gandee, Patrick, Evaluation Methodology for Air Defense Command and Control System, M.S. Thesis, Naval Postgraduate School, Monterey, CA, March 1986.

14. Gandee, P., Grey, M., and Sweet, R., "Evaluation of Alternative Air Defense Architectures," Signal, pp. 47-58, January 1987.

15. Hirsch, Edward, "Evolutionary Acquisition of Command and Control Systems," Signal, pp. 39-45, September 1985.

16. HQ, V Corps, V Corps DCP Project/Caravan Guard III After Action Report, Frankfurt, West Germany, June 1982.

17. Rankin, Robert, "The Evolution of A C3 System Using Nondevelopmental Items," Signal, pp. 58-61, August 1984.

18. Sweet, Ricki, "Preliminary C2 Evaluation Architecture," Signal, pp. 71-3, January 1986.

INITIAL DISTRIBUTION LIST

1. Defense Technical Information Center 2
   CameronStation
   Arlington, VA 22304-6145

2. Library, Code 0142 2
   Naval Postgraduate School
   Monterey, CA 93943-5002

3. MAJ Thomas J. Brown, USAF, Code 62Bb 1
   Naval Postgraduate School
   Monterey, CA 93943-5000

4. Dr. Ricki Sweet 1
   1300 Crystal Drive
   #1704
   Arlington, VA 22202

5. The BDM Corporation 1
   7915 Jones Branch Drive
   ATTN: Mr. John Nevins, Director, Tactical C3 Systems
   McLean, VA 22102-3396

6. LTC Robert Laird 1
   Defense Nuclear Agency
   Nuclear Assessment Directorate
   Washington, DC 20305-1000

7. Commander 1
   HQ TEXCOM (Prov)
   ATTN: ATCT-BA
   FT Hood, TX 76544-5065

8. Dr. Michael Sovereign 1
   USRADCO STC
   APO New York 09159
   SHAPE

9. Dr. Alexander Levis 1
   Massachusetts Institute of Technology
   35-410/LIDS
   Cambridge, MA 02139

10. MAJ Patrick Gandee.. 1
OJCS/C3SA, ATTN: J6A
Room 1D825, The Pentagon
Washington, DC 20301-5000

11. BG Edward Hirsch (Ret).. 1
Director, Center for Acquisition Management Policy
Defense Systems Management College
Fort Belvoir, VA 22060

12. COL Gary Coe 1
OJCS, ATTN: J6F
Room 1D827, The Pentagon
Washington, DC 20301-5000

13. MAJ Nicholas Hoffer.. 1
HQ USMC
CCP-17
Washington, DC 20380

14. Commander.. 1
US Army Signal Center & Fort Gordon
ATTN: ATZH-POO
FT Gordon, GA 30905-5300

15. Joint Command, Control and Communications Academic Group 1
Code 39
Naval Postgraduate School
Monterey, CA 93943

16. CPT Paul V. Maggitti... 5
1130 Spruance Road
Monterey, CA 93940

17. CPT John Dirksen 1
17629 Windward Terrace
Bellflower, CA 90706

18. Commander.. 1
US Army Combined Arms Combat Development Center
C3I Directorate
FT Leavenworth, KS 66027-5300

19. Joint Command, Control and Communications Academic Group 1
Code 74
Naval Postgraduate School
Monterey, CA 93943

20. Ms. Julia Mathews 1
c/o Sweet Associates, LTD.
2001 Jefferson Davis Highway, Suite 1010
Arlington, VA 22202

21. Mr. Charles Hankins
c/o The BDM Corporation 1
7915 Jones Branch Drive
McLean, VA 22102-3396

22. DASD C3 1
Room 3E160 The Pentagon
ATTN: Mr. Lubarsky
Washington, DC 20301-3040

23. LTC James Singer 1
HHC V Corps
ATTN: CCA
APO NY 09079

24. Commander 1
HHC V Corps
ATTN: SGS
APO NY 09079

Thesis
M27556 Maggitti
c.1
An evaluation of the Defense Nuclear Agency exploratory development program in support of TNF C3 survivability (support of V Corps/8ID dispersed command post) using MCES.